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July 25

No. 60. July 1876. [2s. 6d.

THE POPULAR

Science Review

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CONTENTS.

What are Bats?
By St. George Mivart, Ph.D., F.R.S. Plate CXXXVI.

The Eighty-Ton Gun, or Woolwich Infant.
By Capt. C. O. Browne, R.A. Plate CXXXVII.

Aquaria; their Present, Past, and Future.
By William Alford Lloyd, Manager of the Crystal Palace Aquarium.

Popoffkas, or Circular Ironclads.
By A. H. Atteridge.

On the Extinct Animals of North America.
By Professor William Henry Flower, F.R.S. Plate CXXXVIII.

REVIEWS.
Darwin's Latest Book—Popular Chemistry—Animal Morphology—Collecting Natural History Objects — Fermentation — Geological Manuals — American Surveys—Botanical Names—Anti-Darwinism—Our Five Senses—Short Notices.

The Loan Collection of Scientific Apparatus at South Kensington.

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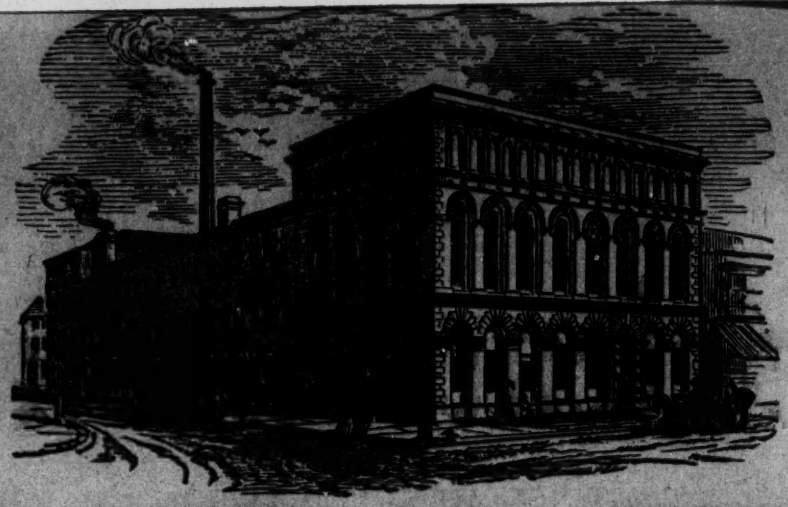

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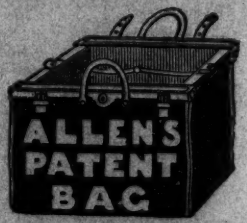

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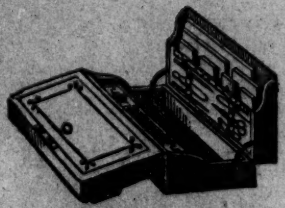

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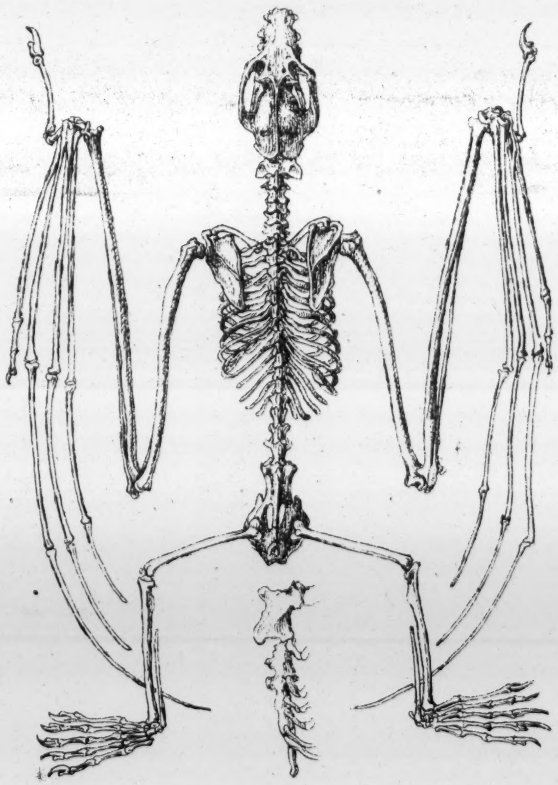

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1.Flying Fox, — Pteropus Whitmeei.
2.Skeleton of Flying Fox.—3.Side view of Sternum.

WHAT ARE BATS?

By St. GEORGE MIVART, Ph.D., F.R.S.

[PLATE CXXXVI.]

THE group of animals called "Bats" is one full of interest to those specially occupied with the study of animal structure—the anatomist, the physiologist, and the philosophical zoologist. At the same time it must be confessed that bats are far from exciting that general interest which in fact they merit. This disregard, however, is very natural. The small size of the bats inhabiting this and other parts of the temperate regions of the globe conspires with their nocturnal habits to remove them from general observation, while the great similarity one to another of their different species is an obstacle to their popularity even amongst zoologists—since it makes their discrimination and classification a matter of difficulty.

Yet bats are, as I hope we shall see, really *very* interesting animals. The bat exhibits to us the body of a beast, specially modified to live the life of a bird, and at the same time serves to give us a fair conception of certain ancient reptilian forms, the remains of which are found deeply buried in deposits made untold ages ago—in the secondary rocks.

But what is a bat? Probably not one of my readers would be likely, if called upon to answer, to fall into the old error of considering it a kind of bird!

All who have ever examined a bat closely, and observed its fur, ears, and teeth, must, I think, have recognised it as a kind of beast. Its real affinities, however, serve excellently well to demonstrate how little mere external aspect can be trusted as a guide to fundamental relationship. The *bat* is essentially an animal of the air—all its structure is modified for flight, and it rarely *descends* to the surface of the ground. The *mole*, on the contrary, is essentially an animal of the earth—all its structure is modified for burrowing, and it rarely *ascends* to the surface of the ground. The contrast could hardly be more complete, and yet the bat and the mole are cousins—the mole, the hedge-

hog, and the shrew mouse belonging to a group of beasts with which the bats show no inconsiderable affinity.

I have spoken of the opinion that the bat is a kind of bird. This view seems to have been entertained by the Jews, and the "bird of darkness" is placed in Deut. xiv., v. 18 amongst the unclean ones forbidden as food:—

"And the stork and the heron after her kind, and the lapwing and the bat."

Aristotle, though he placed the bats amongst flying animals, and therefore amongst birds, distinctly recognised the differences in their organisation, and the same thing may be affirmed of Pliny. But in spite of this, and although Albertus Magnus, in the Middle Ages, was fully acquainted with the true nature of bats, as beasts, as well as with their winter torpidity, we find later on a retrogression of opinion.

Thus Belon, in 1557, in his *Histoire de la Nature des Oyseaux*, includes bats with his birds. At the same time, he was not unacquainted with the mode of their reproduction, as the following verse proves:—

> La souris chauve est un oiseau de nuict
> Qui point no pond; ains ses petits enfante,
> Lesquels du laict de ses tetins sustante,
> En petit corps grande vertu reluit.

Yet later—by nearly a century—in 1645, Aldrovandus decided that bats were rather birds than beasts, and this in spite of his careful study of them, as proved by his beginning to distinguish their different kinds one from another.

Some twenty-five years later, Ray gave them their true position amongst quadrupeds—a position which they have ever since retained.

The Teutonic mind seems early to have appreciated the true nature of bats, as we may judge from the German name, *Fledermaus*, and the old English term, *flittermouse*.

Let us look a little closely at our subject of to-day—the bat.

In the first place, there is a little rounded body, covered with soft fur, which is indeed, what Shakspeare calls it, "wool," when giving the ingredients of the cauldron of Macbeth's witches.

There is a small head, little eyes, large ears, a tail, and two pairs of limbs of very unequal size. The hind pair (the legs) are of moderate length and singularly disposed, so that the knees are turned almost backwards, like our elbows.

Each leg terminates in a foot, furnished with five toes, each with a long, curved claw, all of about the same length. These toes are not webbed, like those of a duck, but are free.

The other pair of limbs (the arms and hands) are of exceeding length. Both the arm and forearm are long—especially the latter—but it is the fingers which are so wonderfully drawn out, and they *are* webbed, like the toes of a water-fowl. Moreover, the web not only connects these long fingers together, but also connects them with the sides of the body and with the legs (as far as the ankle); and does not stop even here, but continues on to the tail, thus connecting it with the two legs.

This large web or membranous expansion has two names. The part belonging to the hand and joining the sides of the body (which is supported by the fingers as an umbrella by its rods) is termed the *alar membrane*. The part connecting the legs with the tail is called the *interfemoral membrane*.

Looking more closely, however, we find that though the four fingers of each hand are thus bound together, the thumb is free, standing out at a wide angle, and furnished with a very long and strong, hooked claw. Of the four fingers, it is only the first which is clawed.

The uses made by the bat of its singularly-formed limbs are, of course, in exact correspondence with their structure. The fore-limbs are true organs of flight; the hind-limbs and tail have a rudder-like action. Besides flight (their predominant mode of motion), bats can crawl upon the surface of the earth with an awkward, shuffling gait. When so crawling, the wings are closed (the long fingers then lying side by side) and the animal rests on its wrists and hind-feet, the body being dragged forward by the help of the strong, hooked thumb nails, which also help it to climb with ease up any rough surface, even though perpendicular.

When at rest, bats usually hang suspended, head downwards, by the claws of their feet, though occasionally they turn round and hang from the claws of their thumbs.

Most nocturnal beasts have large eyes, but most bats have very small ones.

This is perhaps due to the fact that bats in their flight are guided by an extraordinarily delicate sense of touch—so delicate as to seem almost like a sixth sense.

Head of Large-eared Bat.
t, Tragus.

The external ear of most bats appears at first to be double—a very small one seeming to stand up inside the larger one. This appearance, however, is due merely to the very large development of a little piece which in ourselves projects backwards as a small rounded process guarding externally the opening of our ear, and called the *tragus*.

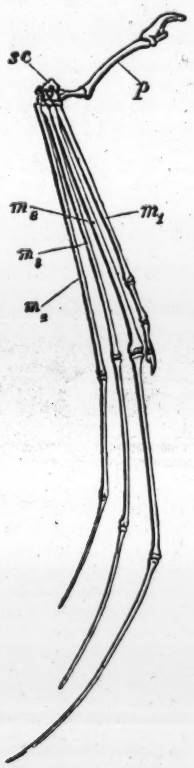
The food of our English bats consists of insects, and their teeth bristle with sharp points, well suited to pierce the chitinous cases by which the bodies of insects are protected.

The stomach (like that of most beasts which live upon a purely animal diet) is a simple, short and rounded bag.

The female is provided with a pair of milk glands, situated on the breast—as in the apes and in man.

The skeleton of the bat, when compared with those of some other animals, affords an excellent example of how fundamental uniformity of structure may underlie forms which are strikingly different—in accordance with diverging habits of life.

I have already called attention to the divergent aspects of the aerial bat and the subterranean mole. Yet the bones of the flying organ of the bat closely resemble that of the burrowing organ of the mole, save as regards the relative shapes and dimensions of the component bones. But while in the bat these bones are drawn out into excessive length and tenuity, in the mole they exhibit the maximum of concentration and robustness. Now both these conditions are but diverging manifestations of the human structure, and the same indeed may be said of such extreme modifications as the fore-leg of the horse or the paddle of the whale.



sc, wrist-bones; *p*, bones of thumb; $m_{1\text{-}4}$, bones of middle part of hands.

But the bat and the mole present us with a special point of similarity in their skeleton not found in the other animals named, including ourselves.

It is that the breast-bone in both the bat and mole develops a median ridge or keel. This keel serves to afford additional surface for the attachment of powerful muscles which pass thence to the arms, and which, in the bat, by their contraction, strike the wings downwards in flight.

Everyone present must have observed, when carving a fowl, that there is a ridge or keel to the breast-bone, and that a voluminous mass of muscle—the breast of the fowl—is situated on each side of such keel. Now, our bat has not got such a mass of muscle on each side of the keel of its breast-bone as has the bird, and for a very good reason. In the bat, as in ourselves, the muscles which antagonise those just noticed (and which draw the arms away from the breast) are situated in the back; but in the

bird, both the muscles which strike the wings downwards, and those which raise them upwards, are both together placed upon the breast, and hence its much deeper and more conspicuous keel. Still, though the muscular structure of the breast of a bat is not so perfectly arranged for flight as is that of a bird, it is an approximation to bird structure, and one we can well understand from the similarity of action. But it may puzzle some of my hearers at first to think why the mole, of all creatures in the world, should have a breast-bone at all like that of a bird. But a moment's reflection will make it obvious that the mole also requires most powerful breast muscles, in order that it may dig its way through the soil with the wonderful speed with which it does dig through it. Similar causes produce similar effects, and thus it is that the mole, like the bat and the bird, comes to have a keeled breast-bone.

The membrane of the bat's wing is a structure of extreme and peculiar delicacy as regards the sense of touch, and the perfection of this sense is doubtless contributed to by a special condition of its blood-vessels. Although the sense of touch depends, of course, directly on the nerves, the functional activity of the nerves depends upon the quantity and the sufficiently rapid renewal of the blood sent to them. This is shown by the familiar examples of numbness brought about by checking the supply of blood to any part with a ligature, as also by the increased sensibility occasioned by inflammation; that is, through a more copious supply of blood. Now, in most animals, as in ourselves, the heart pulsates with rhythmical contractility: but the blood-vessels which distribute the blood over the body are not themselves contractile, however highly elastic they may be. In the bat's wing, however, the vessels which convey blood towards the heart (*i.e.* the veins) have been found by Dr. Wharton Jones to be themselves positively contractile, and so fitted in a most exceptional manner to help on the blood supply, thus indirectly augmenting the power of touch.

This exceptional condition of the vascular system may then have something to do with that exceptional perfection of the power of sensation before referred to, and which was experimentally demonstrated by Spallanzani. He found, not having the fear of anti-vivisectionists before his eyes, that bats deprived of sight, and as far as possible also of smell and hearing, were still able not only to avoid ordinary obstacles to their flight in strange localities, but even to pass between threads purposely extended in various directions across the room in which the experiments were made. This skill it is believed is due to an excessively delicate power of sensation possessed by the flying membrane—a power enabling the creatures by atmospheric pressure and vibration to feel, before contact, the nearness of

adjacent objects. Dr. Dobson, who has paid more attention to bats perhaps than any other living naturalist, is disposed to think, and very reasonably so, that tactile power may be thus greatly increased by such increase of the surface on which tactile sensations may be received as is found in the bat's wing, and that this is the explanation of the mysterious power revealed to us by Spallanzani.

The flight of the bat compared with that of most birds is excessively fluttering; but it is a true and perfect flight, and therefore very different from the analogous action of other beasts called "flying," such as the flying squirrels, the flying opossums, and the flying lemur. In these animals the skin of

A Flying Frog.

the flanks can indeed be extended outwards to the arm and the leg, and when so stretched (as when these animals take long jumps) seems as a sort of parchment to sustain them somewhat in the air, and so far break their fall as to enable them to flit from one bough to another; but they cannot truly fly. The flying lemur is the best furnished in this respect, as it has not only a very extensive "alar membrane," but a short expansion of skin connects together not only the fingers but the toes also

(which is not the case in bats), and has a true interfemoral membrane extending from the hind-legs to the tail.

There is no other such instance in beasts, or in any existing reptiles; but web-footedness is carried to such an extreme degree in a certain frog found in Borneo as to give rise to the conjecture that it was a flying animal.

Mr. Wallace, in his travels in the Malay Archipelago, encountered in Borneo a tree-frog (*Rhacophorus*) to which he considered that the term "flying" might be applied. He tells us:—

"One of the most curious and interesting creatures which I met with in Borneo was a large tree-frog, which was brought me by one of the Chinese workmen. He assured me that he had seen it come down in a slanting direction from a high tree as if it flew. On examining it I found the toes very long and fully webbed to their extremity, so that, when expanded, they offered a surface much larger than the body. The fore-legs were also bordered by a membrane, and the body was capable of considerable inflation. The back and limbs were of a very deep shining green colour, the under surface of the inner toes yellow, while the webs were black rayed with yellow. The body was about four inches long, while the webs of each hind-foot, when fully expanded, covered a surface of four square inches, and the webs of all the feet together about twelve square inches. As the extremities of the toes have dilated discs for adhesion, showing the creature to be a true tree-frog, it is difficult to imagine that this immense membrane of the toes can be for the purpose of swimming only, and the account of the Chinaman that it flew down from the tree becomes more credible."

Although no existing reptile is thus furnished, there is a small Asiatic lizard which is ordinarily spoken of as "flying," the *Draco volans*. And, in fact, though this creature cannot truly fly, but only flit, it has a membrane which can be extended from each side of the body, and which, like the bat's wing, is supported by a number of bony rods. These rods, however, are not, as in the bat, enormously elongated fingers, but are elongated ribs, which stand out freely from the body when jumping, but otherwise are folded back against the flanks.

Existing reptiles, then, present us with no close resemblance to bat-structure; but when we come to extinct reptiles—reptiles which flourished during and anterior to the deposition of our chalk cliffs—the secondary or mesozoic period—we there find reptiles to have existed which present the most striking analogies with existing bats in all that regards their modes of locomotion, and their structure as far as it is related to such modes of locomotion.

These reptiles flew, in the same way that bats do, by means of a vast membrane extending from each enormously elongated hand to the adjacent side of the body.

While, however, in the bat all the fingers of each hand are enormously elongated (to support the alar membrane)—the thumb alone remaining free—in these flying reptiles only a single finger of each hand was thus elongated, the others remaining short, and being provided with claws like the thumb.

With the approach of the winter season bats (like dormice) fall into a peculiar state of winter sleep called hibernation. For this purpose they generally assemble together in large numbers, in out-of-the-way places—caverns, hollow trees, or the roofs of buildings—hanging head downwards by the claws of their feet. During this condition the most important functions of life—breathing and the circulation of the blood—are performed only with exceedingly reduced activity, the temperature of the body becoming notably diminished.

Some of our English bats may be kept in confinement and partly domesticated for a time, small pieces of raw meat being given to them in lieu of their natural insect foot. Speaking of the long-eared bat, Mr. Bell tells us: "It is more readily tamed than any other, and may soon be brought to exhibit a considerable degree of familiarity with those who feed and caress it. I have frequently watched them when in confinement, and have observed them to be bold and familiar even from the first. They are very cleanly; not only cleaning themselves after feeding, and at other times, with great assiduity, but occasionally assisting each other in this office. They are very playful, too, and their gambols are not the less amusing from their awkwardness. They run over and against each other, pretending to bite, but never harming their companions of the same species; though I have seen them exhibit a sad spirit of persecution to an unfortunate Barbastelle which was placed in the same cage with them. They may be readily brought to eat from the hand, and my friend Mr. James Sowerby had one which, when at liberty in the parlour, would fly to the hand of any of the young people who held up a fly towards it, and, pitching on the hand, take the fly without hesitation. If the insect were held between the lips, the bat would then settle on its young patron's cheek, and take the fly with great gentleness from the mouth; and so far was this familiarity carried, that when either of my young friends made a humming noise with the mouth in imitation of an insect, the bat would search about the lips for the promised dainty."

One of the "young friends" here referred to is now the esteemed secretary at the Botanical Gardens, and he has assured me of the truth of the anecdote.

The cry of the bat is exceedingly shrill, so much so that some persons' ears are quite unable to detect it.

Homer compares the voices of the ghosts to the cries of bats. In the 24th book of the Odyssey, 6, he says: "As when bats in a corner of a great cave, when one of them has fallen from off the cluster—so they (the ghosts) went along screaming."

Or, as Pope gives it:—

> Trembling the spectres glide, and plaintive vent
> Their hollow screams along the deep descent,
> As in the cavern of some rifted den,
> Where flock nocturnal bats, and birds obscene;
> Clustered they hang, till at some sudden shock
> They move, and murmurs run through all the rock.
> So cowering fled the sable heap of ghosts.

Bats bring forth but one or two young ones at a birth—when they are received into the interfemoral membrane as into a cradle—the mother then hanging suspended not by her feet but by her thumbs.

The young are born naked and blind, and are suckled at the breast much as is the human infant.

There are many kinds of bats, though their number is uncertain.

There *are* some 14 species even in England, and at least 320, arranged in some 79 genera, in the world at large.

One of our English bats, already referred to as "the long-eared bat," does indeed merit its name, since it has relatively the largest ears found in the whole animal kingdom, being about equal to the length of its entire body. They are capable of being folded up, and generally are so folded, during sleep.

Another kind of bat found in England is called the leaf-nosed bat, because in it not the ear but the nose is the seat of extraordinary skin development—productions of skin curiously folded surrounding and surmounting the external nostrils.

The use of this membrane, according to Dr. Dobson, is to serve as a tactile organ (like the wings); and this is the more probable, seeing that that family of leaf-nosed bats which is represented in England have the smallest eyes, and are devoid of a tragus or inner part of the seemingly double ear before spoken of.

NOSE-LEAF OF THE BAT
Megaderma.

Bats are divisible into two great groups. One of them includes all the insect-eating bats (with or without nose-leaves), more or less like the bats which inhabit this country. They have almost always teeth such as those already described, often a very large tragus to the ear, and a stomach

short and rounded, or at least not prolonged at its pyloric (or more specially digestive) extremity.

These bats are subdivided into various families, three of which alone immediately concern us. 1. The *Vespertilionidæ*, which

British Bats.

includes, amongst very many others, all the English bats without a nose-leaf. 2. The *Rhinolophidæ*, which includes, amongst very many others, the English leaf-nosed bats; and 3. the *Phyllostomidæ*, or leaf-nosed bats of America.

The other group of bats are made up of those, mostly of large

size, called *flying foxes*, of which we have specimens now living in the Zoological Gardens. They are confined to the tropical and subtropical regions of the Old World and the Pacific, but are not found even in the hottest regions of South America. They have grinding teeth, which are not drawn out into sharp points, but have their crowns marked simply with a longitudinal furrow, in accordance with their fruit-eating habits, and their stomach (also in accordance with this habit) is much prolonged at its pyloric, or more specially digestive, end.

Certain leaf-nosed bats of South America go by the formidable name of vampires, from their reputed blood-sucking habits.

Although such a habit could only have been attributed erroneously to the entire group, one certain kind of this group is very truly blood-sucking, and its organisation is peculiarly and very strikingly modified to efficiently subserve this function.

The bat in question is called *Desmodus*, and the truth as to its blood-sucking habit has been fully established by the testimony of Mr. Darwin.* He tells us: "The vampire bat is often the cause of much trouble, by biting the horses on their withers. The injury is generally not so much owing to the loss of blood, as to the inflammation which the pressure of the saddle afterwards produces. The whole circumstance having been lately doubted in England, I was therefore fortunate in being present when one (*Desmodus d'Orbignyi*) was actually caught on a horse's back. We were bivouacking late one evening near Coquimbo in Chile, when my servant, noticing that one of the horses was very restive, went to see what was the matter, and, fancying he could distinguish something, suddenly put his hand on the beast's withers, and secured the vampire. In the morning the spot where the bite had been inflicted was easily distinguished from being swollen and bloody. The third day afterwards we rode the horse, without any ill effects."

The special modifications of structure which harmonise with this special function are mainly two. First, the form of the teeth, and secondly that of the stomach.

As to the teeth, the grinding ones are reduced to a minimum both as to size and number; while the two middle or cutting teeth of the upper jaw are of great size, with a sharp cutting edge well fitted to inflict the small incision needful for the animal's nourishment.

TEETH OF THE VAMPIRE BAT. *Desmodus.*
i, cutting-teeth; *c*, eye-teeth.

As to the stomach, it presents us with a structure unique in the animal kingdom. Here it is not the pyloric end of the stomach, but the opposite or cardiac end,

* "Journal of Voyage of Beagle," vol. i. p. 22.

which is produced into an enormously long pouch, while the opposite or pyloric end is reduced to a mere rudiment—the highly nutritious food (blood) requiring very little digestion, but needing a capacious chamber for its speedy reception.

Although this is the only bat perfectly organised to live by blood-sucking exclusively, nevertheless it is probable that various other kinds practise blood-sucking as at least one part of their mode of nutrition.

The late distinguished zoologist belonging to the Zoological Society—Mr. Blyth—has observed this habit in a leaf-nosed bat of India, one belonging to quite another family from that to which the American vampire belongs. The bat in question is called *Megaderma Lyra*. Respecting its habits Mr. Blyth tells us* as follows:—

"Chancing one evening to see a rather large bat enter an outhouse from which there was no other egress than by the doorway, I was fortunate in being able to procure a light, and thus proceed to the capture of the animal. Upon finding itself pursued, it took three or four turns round the apartment, when down dropped what at the moment I supposed to be its young, and which I deposited in my handkerchief. After a somewhat tedious chase, I then secured the object of my pursuit, which proved to be a fine pregnant female of *Megaderma Lyra*.

"I then looked at the other bat which I had picked up, and, to my surprise, found it to be a small *Vespertilio*, nearly allied to the European *V. pipistrellus*, which is exceedingly abundant, not only here, but apparently throughout India, being the same also, to all appearance, as a small species which my friend Dr. Cantor procured in Chusan. The individual now referred to was feeble from loss of blood, which it was evident the *Megaderma* had been sucking from a large and still bleeding wound under and behind the ear; and the very obviously suctorial form of the mouth of the vampire was of itself sufficient to hint the strong probability of such being the case. During the very short time that elapsed before I entered the outhouse, it did not appear that the depredator had once alighted: but I am satisfied that it sucked the vital current from its victim as it flew, having probably seized it on the wing, and that it was seeking a quiet nook where it might devour the body at leisure. I kept both animals wrapped separately in my handkerchief till the next morning, when, procuring a convenient cage, I first put in the *Megaderma*, and, after observing it some time, I placed the other bat with it. No sooner was the latter perceived than the other fastened

* In the "Journal of the Asiatic Society of Calcutta," vol. xi. p. 225, quoted in P.Z.S. 1872, p. 713.

on it with the ferocity of a tiger, again seizing it behind the ear, and made several efforts to fly off with it; but, finding it must needs stay within the precincts of the cage, it soon hung by the hind-legs to one side of its prison, and, after sucking its victim till no more blood was left, commenced devouring it, and soon left nothing but the head and some portions of the limbs. The voidings observed very shortly afterwards in its cage resembled clotted blood, which will explain the statement of Stedman and others concerning masses of congealed blood being always observed near a patient who has been attacked by a South African vampire. Such, then, is the mode of subsistence of the *Megaderma*."

Bats are most widely diffused over the surface of the globe—as their powers of flight might lead us to expect. Even Australia—so very peculiar in the character of the other beasts which inhabit it—possesses bats belonging to both of the bat families which are found in our own island.

But although the whole group of bats, and also that family to which most English bats belong—the *Vespertilionidæ*—are thus widely distributed, the geographical limits of some families of bats are very sharply defined.

To appreciate these facts it is necessary to be acquainted with the geographical areas into which the surface of our globe may be divided, each considerable tract of the earth's surface having its more or less peculiar animal population, or *fauna*, as it has its indigenous plants; that is, its *flora*. The earth's surface is divisible into six zoological regions.

1. The *Palæarctic region*, or Europe, Asia north of the Himalaya, and Africa north of the Sahara.
2. The *Ethiopian region*, or Africa south of the Sahara, and including Madagascar and also Arabia, which geologically is part of Africa.
3. The *Oriental region*, or Asia south of the Himalaya, with Southern China and the Philippine Islands and Indian Archipelago as far as the island of Baly.
4. The *Australian region*, or Australia, New Zealand, the less remote Pacific Islands, and those of the Indian Archipelago from New Guinea up to Lumbock.
5. The *Neotropical region*, or South America, together with tropical North America and the West Indies.
6. The *Nearctic region*, or temperate North America and Greenland.

Now the whole group of flying foxes is strictly confined to the tropical regions of the Old World and Australia. In the same way the family of leaf-nosed bats like those of England—the *Rhinolophidæ*—is limited to the Old World, though reaching there much higher latitudes than do the flying foxes.

The groups to which the vampires belong—the *Phyllostomidæ*—is strictly confined to the Neotropical and Nearctic regions; and the Neotropical region is not only distinguished as the head-quarters of the *Phyllostomidæ*, but also by being altogether destitute of the flying foxes and *Rhinolophidæ*.

Such being the relation of bats to space—their geographical distribution—what are their relations to time—their geological distribution?

I assume that my readers are acquainted with the fundamental facts and laws of geology, and know that the successive layers, of which the superficial crust of the earth is in very various degrees composed, are classifiable into three sets: (1) The Primary or Palæozoic rocks, (2) the Secondary or Mesozoic rocks (from the Trias to the Chalk inclusively), and lastly (3) the Tertiary or Cainozoic rocks, extending upwards from the Chalk to the present day.

Remains of beasts more or less closely resembling some of those existing now in Australia are found low down in the secondary rocks, namely in the Triassic and Oolitic formations. Generally speaking, however, beasts such as those which now exist are not found deeper than the Tertiary strata, and this is the case with bats.

The oldest fossil bat yet known is represented by a few teeth found in Eocene deposits in Suffolk. The oldest perfect fossil bat is the *Vespertilio parisiensis* of the gypsum beds of Montmartre, near Paris.

Some forms of existing beasts, however, which are *now* distinct enough, such as the ox and the pig, or the tapir and the horse, were preceded in early Tertiary times by others which were more or less intermediate in structure. This is not the case as regards bats. Bats, as soon as they appear at all, appear as thoroughly and as perfectly organised bats as are those living amongst us now.

This leads us to speculate upon questions of origin; but, before so doing, let us see that we have a clear idea of what a bat is, and can give a good definition of it.

In order that we may have this clear idea, we must consider for a few moments zoological classification.

The whole group of animals is fancifully termed the animal kingdom, in contradistinction to the world of plants—the vegetable kingdom.

This vast mass of animals is subdivided into a number of very large groups, each of which is called a subkingdom. Thus we have the subkingdom to which we ourselves belong—the vertebrate subkingdom; the subkingdom of insects, &c.; that of snails, cuttle-fishes, &c., and so on.

Each of these various subkingdoms is again divided into

certain subordinate, but still very large, groups, each of which is called a class.

Thus the subkingdom Vertebrata is made up of the class of man and beasts, that of birds, that of reptiles, that of frogs, toads, and efts, and that of fishes.

Every class is again subdivided into certain subordinate groups, termed orders.

Each order is composed of families, each family of genera, and each genus of its component kinds or "species."

Now the bat, as already said, belongs to man's own class, possessing as it does all the characters which distinguish that class from the other classes of vertebrate animals.

Man's own class, Mammalia, is divisible into some dozen orders, and all the bats form one such order (*Cheiroptera*), into which no animal but a bat is admitted. The characters of this order are the possession of a truly flying membrane, sustained by very elongated fingers; and the bat is capable of being very shortly defined—namely, as *a truly flying mammal.*

Bats present no real resemblance whatever to birds, but are of course much more like ourselves (who are their class-fellows) than they are like any bird.

Similarly, in spite of this analogical relation of bats to those extinct reptiles, the pterodactyles, these creatures have no true affinity. Pterodactyles are aerial modifications of the Reptilian type, just as bats are aerial modifications of the Mammalian type. We may say, in a rough and general way, as pterodactyles are to reptiles, so are bats to mammals.

Before concluding, we may now glance at the question of the genesis or origin of bats. To those who accept the doctrine of Evolution—as I myself do—there can be no question but that bats did arise by natural generation from some anterior beasts which were not bats. But at what period, and from what progenitors? these are questions which it is quite impossible to answer at present. As has been said, there are certain cases in which we may imagine now existing more highly specialised and differentiated forms were developed from anterior less highly specialised and differentiated ones. We may do so, *e.g.*, as regards the horse and the ox. But we cannot do so as regards the bat, because up to the present time no fossil remains whatever have been found which connect bats with other creatures. Moreover, the development of the bat's wing, difficult as it is to conceive upon any view of evolution, seems to me to be especially difficult as the mere result of the survival of the fittest, when we consider the origin of the initial stages of the organ. The nearest existing relatives of the bat which are not bats are perhaps the little shrew mice belonging to the order Insectivora. Some of these are aquatic;

and it is conceivable, though there is no fragment of evidence in favour of it, that some ancestral aquatic form may have developed long fingers and webs like those of the flying frog. This speculation does not, however, commend itself to my mind as a satisfactory one; and though doubtless, could we see all the extinct forms of life which have existed during the secondary period, we should find some creatures developing by more or less rapid stages along a definite course in the direction of the type of structure selected for our consideration to-day, and though I am ready to make an act of scientific faith in the existence of such creatures, I confess my imagination fairly baffled in its attempts to depict them, or the road which this particular course of evolution followed. We must wait patiently for more light from palæontology. But we may wait very hopefully. We may do so because the wonderfully rich harvest of fossil remains now being gathered in North America supplies us with good and solid ground for hope.

Already forms have been discovered there so strange that they cannot be satisfactorily grouped in any existing order of mammals—forms such as imagination could hardly have anticipated. We may, then, not unreasonably expect that sooner or later—perhaps very soon—fossils deeply buried in the secondary rocks will come to light, clearly pointing out the line which has been followed in the evolution and development of the only truly flying mammal—the bat.

EXPLANATION OF PLATE CXXXVI.

FIG. 1. A Flying Fox from Samoa, *Pteropus Whitmeei*.

FIG. 2. Skeleton of a Flying Fox.

FIG. 3. Side view of breast-bone of ditto.

THE EIGHTY-TON GUN, OR WOOLWICH INFANT.

By Captain C. O. BROWNE, R.A.

[PLATE CXXXVII.]

THE appellation of the "Woolwich Infant" was originally given to the first 35-ton gun. We are now about to consider a "new arrival" of not only vastly greater power, but one which, starting in certain respects, as it does, on new conditions, may be regarded as the herald of a race of giants.

The circumstances which have called the 80-ton gun into existence are those under which the struggle for supremacy between guns and armour is now carried on. It becomes necessary, therefore, to glance briefly at the stage of development to which this branch of warfare has been pushed.

Our first armour-plated vessel, the *Warrior*, was commissioned about 1861. She carried 4½-inch plates on the greater part of her sides, with 18 inches of teak backing and ¾-inch inner skin of iron. This was found to resist fairly the attacks of 7-inch Armstrong breech-loading guns and 68-pounder smooth-bores, except at very close distances. Great strides were shortly made in the manufacture of guns; but at the same time the naval constructors arrived at such forms and designs for vessels as enabled them to carry much heavier armour, decreasing the surface of the side to be plated by lowering the freeboard, by shortening the entire vessel, and further by greatly diminishing the size of the batteries requiring to be surrounded, as it were, with an iron wall. This was done by drawing the guns into a centre battery, or placing them in turrets on Captain Cole's system. Thus it has come to pass that in our fleet, at this present time, we have on the one hand the *Warrior* and the *Minotaur* or *Northumberland* class of ships, with 4½ inches of iron and 7-inch (Woolwich) guns of 6½ tons weight, and on the other hand the *Devastation*, *Thunderer*, and *Glatton*, with 14 inches of plate and 35 and 38-ton guns; while the *Inflexible* is now being constructed with 24 inches of armour laid on in two plates of 12 inches each, and is to carry 80-ton guns. So rapid

a development of power is obviously alarming in more than one respect; for not only are we compelled to devote enormous sums of money to the construction of such designs, but also the new vessels so rapidly dwarf and outmatch their predecessors in their means of attack and defence, that there must necessarily exist in the armament of each nation a few ships which are able to dispose of all comers except the individuals of about their own class, who might probably be a number that might be counted on our fingers. An uncomfortable element of uncertainty is thus brought into the question of naval warfare, for the same conditions obtain in the fleets of all formidable naval Powers. Suppose that England, in the *Inflexible* and *Dreadnought*, has vessels that are decidedly more powerful than any of her enemy's fleet. Suppose even that the next class of ship, the *Devastation* and *Thunderer*, are sufficiently powerful to be expected to hold their own fairly against the most formidable antagonist, which we shall see hereafter is not the case. What guarantee have we that vessels, say such as the *Monarch*, may not be called upon to engage with that antagonist? So that a ship which we look upon as rather a powerful ironclad may after all be placed in circumstances when she may be called upon to contend against an invulnerable antagonist whose guns, under favourable conditions, are capable of piercing her own armour with ease. This danger is seen to be the greater when the difficulty of identifying an antagonist is taken into account. One thing at all events is clear, and it is that which at present concerns us. Our vessels must be supplied with the most powerful guns we can make. Hence the importance of the 80-ton gun and its kindred. The particular desideratum demanded of the 80-ton gun was, that it was to be capable of penetrating 20 inches of iron, firmly backed, at 1,000 yards range. This there is reason to hope is likely to be realised, as we shall see hereafter, but we have first to deal with what has actually taken place.

The gun itself (*vide* Pl. CXXXVII. fig. 1) is made on the Woolwich system as perfected by Mr. Fraser; that is to say, the centre portion or "A tube" is made of a block of cast steel supplied by Messrs. Firth. Round this are "built up" five cylinders formed of coiled wrought iron, and a large mass termed the trunnion hoop, which are attached in succession in their proper places by means of heating them so as to expand them and enable them to pass on, and then in cooling to grip the interior portion firmly. The breech end behind the base of the steel tube is closed by a block of wrought iron screwed into the posterior portion of the "breech-piece" coil. Those who are acquainted with the manufacture of the Woolwich guns will recognise that this amounts to saying that

FIG. 1.—T

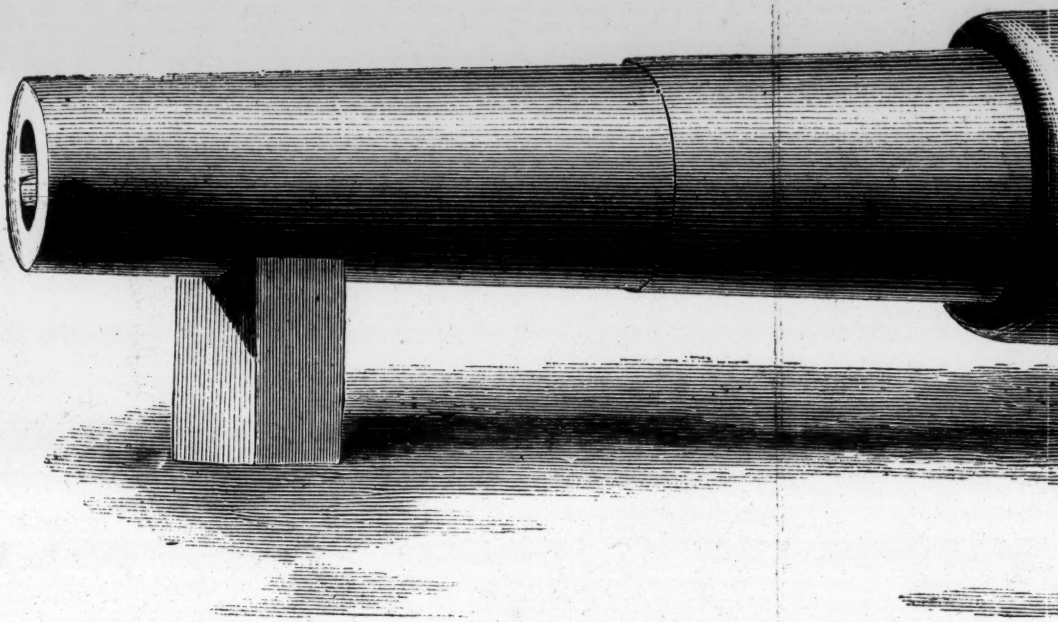
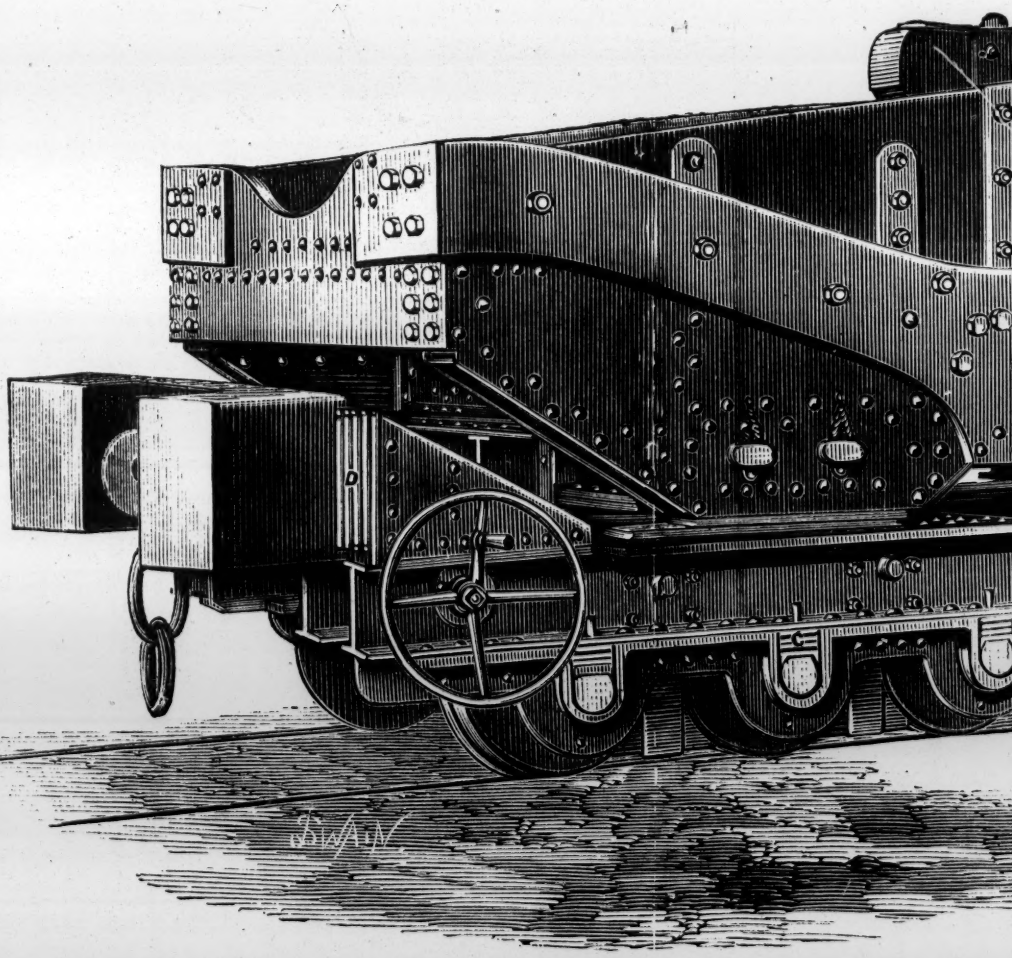
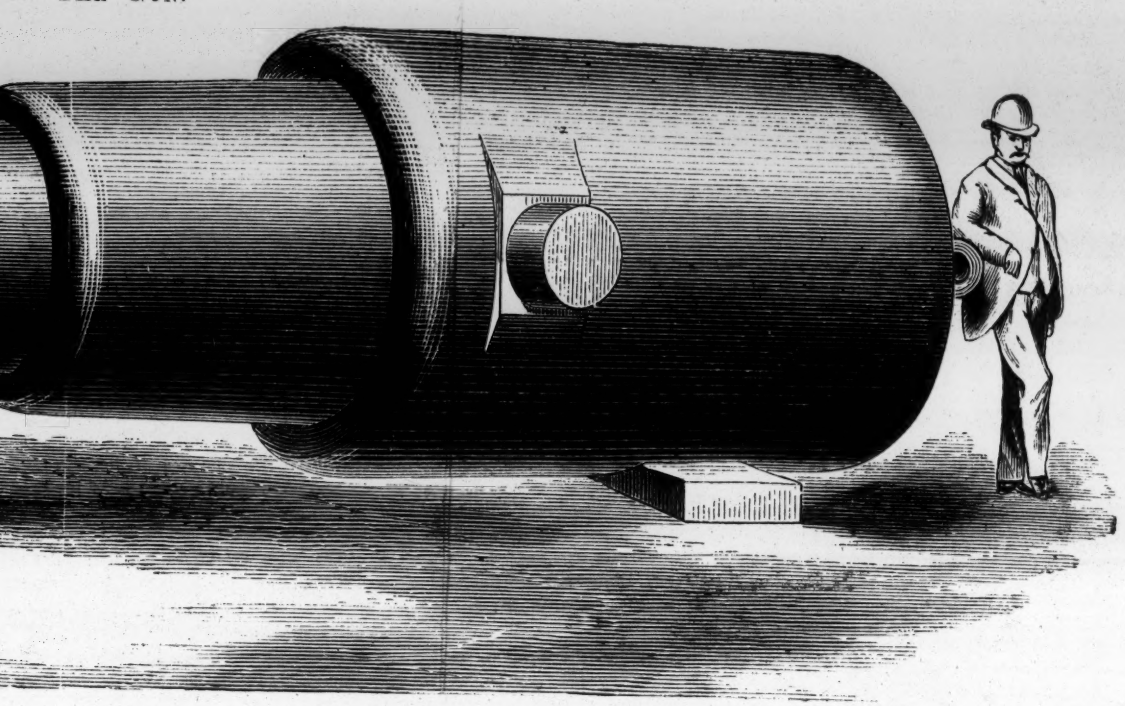


FIG. 2.—THE

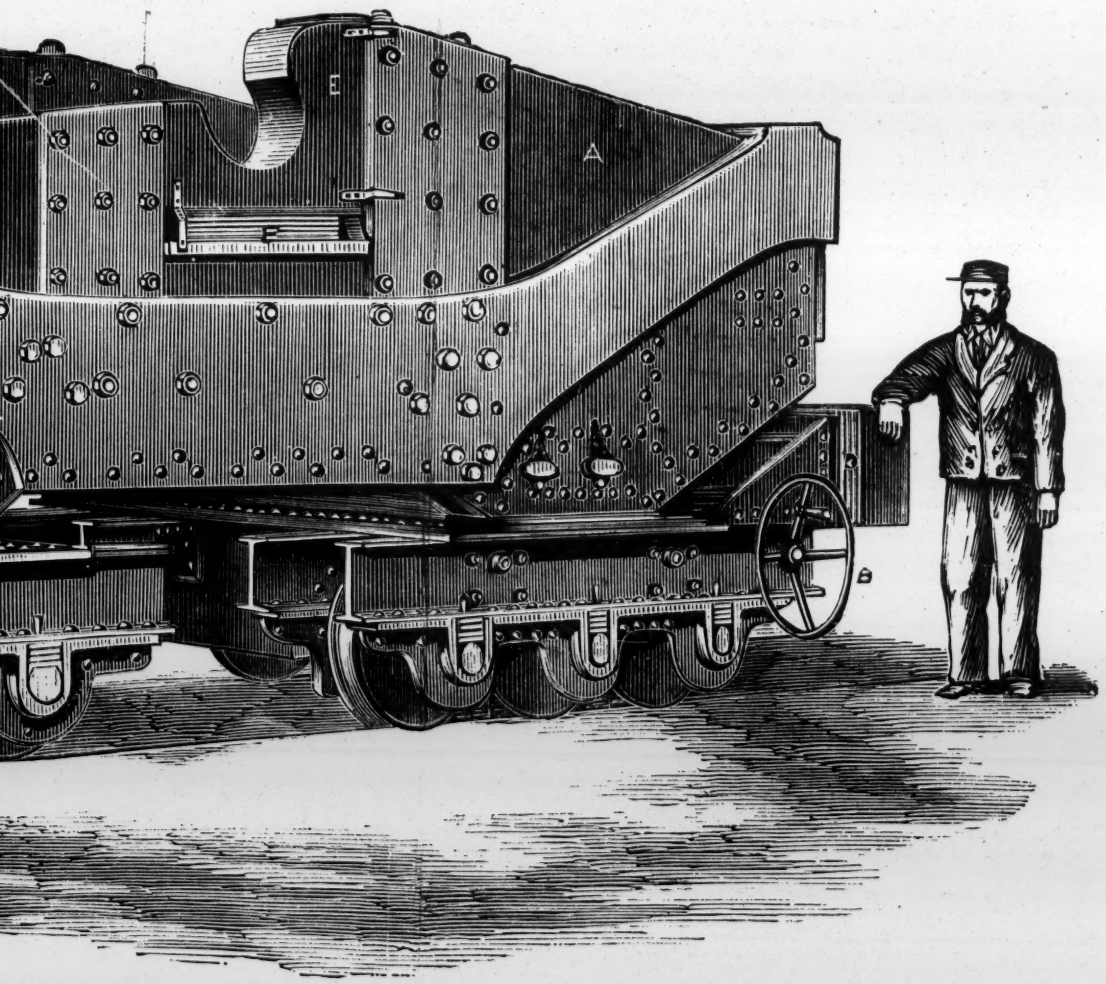


1.—THE GUN.

[*To face p.* 242.



—THE CARRIAGE.



OLWICH INFANT.

this piece is constructed on the Fraser system. The steel tube is roughly bored out before the gun is built up and finished, and rifled afterwards. The total weight of the iron forgings and other separate parts to be thus united is given by Major Maitland, the Assistant-Superintendent of the Gun Factories, in a paper sent to the R.A. Institution, as 164 tons 16 cwt. when in the rough state.

In the manner just described a gun can be made, so it is believed, as strongly as is possible on any system. It is difficult to speak positively, because steel guns are frequently found to be very strong, and when tested to destruction they have exhibited greater durability than was thought could have been shown by any other material. Possible or probable durability of a high character, however, is not at all so desirable an element to exist in a gun as the *positive assurance* of some standard, even though a much lower one. This is what may be claimed for wrought-iron guns compared with steel. The former are very reliable, and possess very high resisting powers; the latter may possess extraordinary powers, but may occasionally burst unexpectedly, and when they do so the fragments fly violently in all directions; whereas should the wrought-iron gun give way, it does so gradually, and so no danger is to be anticipated. The conditions which principally have to be considered, at all events with the Woolwich guns, are those under which the bore of the gun may best perform the work required of it, and resist the effects of wear and tear caused by the erosion of the gas, our guns having worn out in many instances very rapidly. Matters have been improved by the introduction of tight-fitting copper gas-checks, which fix on to the base of the projectiles, and prevent the gas from escaping past their sides, and so scoring the bore of the gun as well as wasting available power. It has been considered desirable, however, that under any circumstances the pressure of gas in the bore of the gun should not be allowed greatly to exceed about 25 tons per square inch. The principal problem involved in the whole question may be thus stated. How are we to discharge the projectile with the desired velocity without bringing on the bore of the gun a pressure exceeding about 25 tons? The size of the bore of the gun affects the question, because much depends on the space it allows the charge to occupy. A larger bore admits of a shorter cartridge, and brings the powder into a more compact mass through which the flame of explosion passes more easily, and so generates the gas more rapidly. Connected with this is the question of giving guns enlarged chambers, so as to burn the powder in a more favourable manner than the desired size of bore would allow. Sir J. Whitworth, in 1872, had great success with a breech-loading gun with an enlarged

chamber, which was probably the first that was tried by anyone. An enlarged chamber with a muzzle-loading gun is rather a more difficult matter to arrange, because in many cases the cartridge has to be made to set up and expand in order to enter the enlarged chamber properly.

A much more complicated question than that of the size of the bore is that of the powder. To understand this, it is necessary to be clear generally as to what takes place in the process of explosion. The word "generally" is used advisedly, for it would be rash for anyone to profess to know all that takes place. Speaking generally, then, the explosive gas commences to be generated by the flash of the tube igniting the surface of the adjacent grains of powder, and the flaming gas so generated rapidly expands in all directions open to it; and thus, under the pressure of close confinement, rushes violently through the interstices between the grains of the entire charge, which grains, becoming ignited, burn from their exterior surfaces towards their centres. Thus the gas developed rapidly acquires sufficient power to drive the projectile up the bore, following it up with all the force it acquires from the further generation of gas as the grains burn through. Thus it will readily be seen that a small grain of powder facilitates rapid explosion by burning through very quickly, and in a small charge of powder gives the greatest effect. As the charge increases, however, there soon comes a point when the interstices between the grains become insufficient for the passage of the flame, and, in fact, the bore becomes choked, so that a larger grain becomes necessary, even where speed is the sole condition to be considered. On the other hand, too large a grain is blown out partially consumed from the muzzle, and so partly wasted. Nevertheless, so great is the evil of violent action, that it is better to err on this side than on the other. A committee was specially appointed to investigate the action of powder in the bore of a gun, who made a series of experiments in 1870, showing by means of Capt. Noble's chronoscope and plug or pressure gauges the velocity of the projectile and the pressure of gas at various points in the bore of a gun. By their labours they arrived at a form of grain which gave a prolonged and continued pressure on the projectile throughout its passage along the bore, without at any one instant causing an excessively high maximum pressure, such as would strain the gun disproportionately. This kind of powder necessitates an increased charge as compared with that which burns more rapidly, because the latter acts at greater advantage by performing its work when the space behind the projectile is smaller. It is much better and cheaper to use more powder than to injure the gun, and so the slow-burning powder is preferred. Obviously, however, it is impossible so to regulate

matters that the powder is exactly burnt up as the shot arrives at the muzzle; and were it so, the pressures, as the projectile got near the muzzle, would be very small, because the burning surface and quantity of gas generated becomes less and less as the grain becomes smaller. Hence it is easy to see the difficulty of avoiding the escape from the muzzle of partially burnt grains of powder, undesirable as that may be.

The word "grain" has been hitherto used on principle; but the form that the grain takes in the charges of the largest guns is that of a rough cube with an edge from $1\frac{1}{2}$ to 2 inches in length, each single grain, or "pebble," as it is called, containing in itself a considerable charge of powder. So far the size of the powder-grain only has been considered. The density, and even the glazing, have also to be taken into account. The density indeed entirely alters the conditions, for not only does powder burn more rapidly as it is less dense, but also, it has been recently shown, the assumption that the grain or pebble burns evenly from the outside to the centre is quite untrue generally, for the pebbles burn through in certain places and become honey-combed or sponge-like during combustion, in all powders of ordinary density, and are blown out of the gun, and may be picked up afterwards in this condition.

The question of the powder has been discussed at some length, because it is necessary to know something of the nature of the problem to be worked out, in order to understand the reason for the long series of experiments that is being now carried on in the Woolwich Arsenal.

In the design of the ammunition there is nothing differing essentially from that of other large guns except the magnitude. The projectiles are eventually to be of the same general form as our other service projectiles. The armour-punching shot or shell have ogival heads and sharp points, and are made of chilled iron on Sir W. Palliser's system. The section of such a head is in the form of a rather pointed gothic arch, and the metal in the head is chilled white and very dense and hard, while that in the body is mottled. Projectiles of this kind have extraordinary powers of penetration; the metal in the head being of the kind to stand up under the compression of impact, and to cleave its path into the soft iron of which armour is necessarily composed, while the base has more tensile strength and holds well together. That the head has the qualities of intense hardness is seen in the fact that the point never flattens, but remains sharp to the end, while the crushing strength of the metal is apparent from the fact that it remains quite cool after impact, while the pieces of plate that have suffered compression are for a considerable time intensely hot.

The final calibre of the gun is intended to be 16 inches,

and the rifling consists of eleven grooves in the bore at a spiral increasing from nothing, or the direct direction, at the bottom of the bore to one turn in 35 calibres at the muzzle. The projectiles have three gun-metal studs for each groove. The weight of the projectile, when the bore of the gun is of its full dimensions, may be about 1,600 lbs., and that of the charge 300 lbs., with a muzzle velocity of about 1,400 feet per second.

The question of the carriage is an interesting one. It was clearly desirable to find some way of facilitating the operations of moving this gun about. Light guns travel on their firing carriages. Heavy guns are generally conveyed entirely separate from their carriages. Indeed their carriages are massive frames of iron, supplied only with small trucks, which are brought into play by hydraulic lifts when the carriage is to run up a few feet along its platform. The carriage and gun are separately lifted by cranes, sheers, gins, and the like; and by the same means the gun is placed on its carriage when mounted, and lifted off and lowered when dismounted. These operations are slow, and such as need much mechanical apparatus, and considerable skill to carry out with safety to those engaged in them, because with exceptionally heavy weights the strain likely to be brought on every part of the gear must be carefully calculated. A weight of 80 tons would be so greatly in excess of any that has hitherto been dealt with, that a special supply of apparatus might have to be made to any place where the gun was to be moved and mounted. Even at the Royal Arsenal the great hydraulic crane, which was hitherto found able to seize up and swing round any desired weight as if it were playing with it, had to be strengthened. The operations of loading and unloading, mounting and dismounting, could not fail to involve considerable expense and difficulty at out-stations. Under these circumstances the idea was suggested of dispensing with them by building a carriage on which the gun might both fire and travel; in fact, to make the monster approach in its conditions to a field piece—with this exception, that its movement was always to be on railway lines, for which purpose the carriage must be made to suit the narrow gauge. Whether this idea originated with the Royal Carriage Department or with Major Maitland of the Gun Factories, it may be hard to say; at all events it is to be highly commended.

The carrying out of it was, however, by no means easy, and Colonel Field and Mr. Butter are to be congratulated on their complete success. To understand the difficulties, the action of a gun in firing must be considered. The carriage is driven back by a violent force applied at the bottom of the bore of the gun. The recoil is then checked gradually by brakes applied

to the trucks. The direct strain the carriage must, under any circumstances, bear; but this is not what it generally suffers from, but rather the contortion that it receives, from the fact that the centre of gravity of the mass cannot be brought opposite to the bottom of the bore of the gun, but must fall below it. A violent horizontal blow backwards, opposed by a resistance in a lower plane, causes obviously a contorting "couple" or twist to be generated, driving the posterior part of the carriage against the ground, and, as a secondary effect, causing the front of it to lift or jump. In our modern heavy gun-carriages this has been brought to a minimum by getting the gun well down between the brackets or cheeks of the carriage, and making the latter as low as possible, so that the bottom of the bore, the centre of gravity of the mass, and the surface on which the carriage slides as it recoils, are brought as nearly into the same plane as possible. With the 80-ton carriage (*vide* Pl. CXXXVII. fig. 2) the evil could not be got over in this way; for the gun-carriage trucks, which were to be also railway trucks, must be capable of running along rails, and round any curves that might exist. The carriage was necessarily very long, the length of the gun itself being 27 feet. Consequently, the only way in which it could be made to turn, was to construct it in the form of an upper carriage resting on "bogies" (*vide* fig. 2). Each of these bogies being attached to the carriage by a single centre pivot, the whole might run round any curve that the bogies could take independently, the carriage adjusting itself like a flexible connection. This, however, necessitated the gun being a considerable height above the trucks, and so called for great strength in the carriage, which would be severely taxed by a downward contorting blow on firing. The carriage is made of iron, except a wood block termed a buttress, which supports the trunnion-hole block at A, and a few other minor parts. Strong india-rubber springs, or buffers of sheet india-rubber an inch thick, are laid in between pieces of iron plate at C C, above the trucks, to prevent shocks or jars in travelling. Hand-wheels are fixed on the front and rear of the ends of the front and rear bogies respectively, which, by means of bell-crank gear, bring double wood brakes to bear on all the trucks. The platform of each bogie consists of longitudinal pieces of angle iron, 12 inches by 6 inches, with $1\frac{1}{2}$-inch web. The carriage rests on gun-metal bearings on the bogies. From what has been said it may be seen that, on firing, a violent backward and downward blow will be given to the carriage through the trunnion blocks at E and F. Here again is india-rubber inserted under pressure, to act as a cushion. It may be seriously doubted how this would do in hot climates. For the service for which the carriage is at present intended, however, it

serves its purpose very well. For proof firing the rails were made to incline upwards to the rear, so that the recoil of the gun would be checked, and the piece easily run up; or it might be made to return immediately into the firing position. When once the gun is mounted on this carriage, there is no necessity for dismounting it. It can travel to any part of England, and be brought into action wherever it may be desired, so long as the ordinary narrow gauge line (4 feet 8½ inches) exists, laid on a permanent way of sufficient strength to carry the gun and carriage, whose total weight will probably be finally about 118 tons.

The gun was at first only bored out to a calibre of 14½ inches, in order to obtain some experience as to the burning of the powder and the behaviour of the projectile before the final dimensions were given to the bore. It was brought down to the proof butts in Woolwich Arsenal, and fired for the first time on September 17 last.

On this occasion six rounds were fired with a projectile of 1,160 lbs. weight, and charges of pebble powder composed of cubes of 1½-inch edge, the weight of the charge gradually increasing from 170 lbs. up to 240 lbs. There is no occasion to enter into the exact details of each round; it is preferable to keep to the object and general results obtained. As mentioned above, the pressure in the bore of the gun was to be kept, if possible, nearly about 25 tons per square inch, and the velocity was to be brought as high as possible consistently with this condition. It has been already explained that the velocity is obtained by measuring the time occupied by the shot in passing over the space between two screens, a current of electricity being broken or interrupted momentarily as the shot cuts the wires of each screen. The pressure was measured by pressure gauges fixed in the base of the projectile and the bottom of the bore of the gun.

The charges were 170, 190, 210, 220, 230, and 240 lbs., which gave pressures on the ball of the shot of 19·4, 18·2, 19·8, 21·4, 21·8, and 27·3 respectively, with 24·2, 23·3, 24·8, 22·2, and 29·6 on the bore for the first five rounds. The velocities at the muzzle were 1,393, 1,423, 1,475, 1,503, 1,550, and 1,550 feet per second. These must be considered good, although as yet the weight of the projectile was but small. A velocity of 1,550 feet is a very high one for a rifled shot. Smooth-bore guns occasionally fire round shot at higher velocities; but the projectile is very light compared with the charge, is easily projected, and loses its velocity rapidly. Those unused to these sort of statistics may form a good idea of the speed of a gun-shot, from the circumstance that an enemy's shot comes to you rather before the report of the guns. You see the flash, but the shot has whizzed past you and done its work so far before

you hear it. That this might be expected is obvious from the fact that the speed at which sound travels is not greatly in excess of 1,100 feet per second; so that for it to overtake the shot a very long range and considerable elevation is required. The pressure against the base of the projectile would naturally be somewhat less than that against the bottom of the bore, because the shot is fast moving away from the gas; but it is a little difficult to explain why the difference is quite so great as it is.

We may run briefly through the succeeding trials of the gun, which have been in pursuit of the same ends as the first; that is to say, the object has been gradually to feel the way experimentally to the condition under which the greatest velocity can be given to the shot without subjecting the gun to a pressure greatly exceeding 25 tons per square inch.

On Nov. 18 and 19, and Dec. 9 and 10 last, fifteen rounds in all were fired, which concluded the trial of the gun at its first calibre of 14½ inches. In March it was again fired, when the bore had been increased to 15 inches; and in May, when the powder chamber had been increased to 16 inches. The general results of these trials have been to show that the powder is better, or at all events more uniform, in its effect as the density is slightly increased above the average; that the employment of a charge over 250 lbs. was unprofitable and wasteful until the calibre arrived at 15 inches; and that the best results, not only those which are least injurious to the gun, can be obtained without increasing the pressure to 30 tons. Of course, as the calibre increases, the power of burning powder to advantage does so too. Probably a 2-inch cube or grain of powder might be employed to greater advantage when the calibre is brought up to the full amount of 16 inches, and the chamber still further enlarged. At present experiments are being continued with 1½-inch cubes, but very promising results were obtained with those of 1¾ and 2 inches during the trials. A projectile of 1,460 lbs. weight has been fired. The enlargement of the chamber appears to have good results, but a sufficient number of rounds have not as yet been fired to enable a certain opinion to be given.

This is the first heavy gun whose chamber has been enlarged; but some successful experiments have been made with field guns in the Royal Arsenal recently. It may be observed we are not as yet finally committed to an enlarged powder-chamber, for the enlargement has at present been limited to the intended final calibre of the gun.

The greatest velocity that has yet been obtained with the 80-ton gun is about 1,550 feet per second.

To pass on to the more interesting question of the probable power and uses of the gun on service.

The most important matter is the power to penetrate armour.

It is obvious that there is no use in one ship directly attacking another whose plates are entirely beyond the power of any guns that can be brought to bear on her; there are other questions, however, that are not so easily disposed of. For example, when two ships engage, as we may assume will commonly occur, who have the power, under favourable circumstances, of piercing each other's sides, how far will a more powerful gun enable a vessel with thinner armour to hold her own by engaging at longer ranges than suits her adversary? This is important, as affecting the question of what benefit our lighter-plated vessels would derive if we put more powerful guns in them. The matter that concerns us chiefly, however, is, first, under what conditions would a heavily-plated ship, such as the *Inflexible*, go into action against vessels now afloat, or against such as are known to be building. Of vessels at present afloat, the most powerful in our own navy are the *Devastation*, *Thunderer*, and *Glatton*, carrying 14-inch and 12-inch armour and 38 and 35-ton guns, throwing 600-lb. shot.

The ships carrying the thickest armour among the navies of foreign Powers that we can hear of as at present afloat are, the Russian circular ships, *Admiral Popoff* and *Novgorod*, the former carrying plating and iron girders, &c., which Mr. Reed estimates as *equivalent* to 18 inches of iron, and the latter armour equivalent to 11 inches. With the 12 inches backing and edge plates of the $1\frac{1}{4}$-inch skin, our 14 inches of armour, which includes the bare thickness of the front plate, is probably quite a match for the former, and probably the guns of the *Popoff* are not nearly as powerful as the 35 and 38-ton guns in our ships. Russia is, however, building a notable ship, the *Great Peter*, which is to carry 15 inches of armour and 40-ton guns. She, therefore, ought to be rather more than a match for the *Thunderer* whenever she is afloat; but there has been much delay and disappointment, and it may be questioned whether we are justified in assuming that she will come up to this standard in all respects. The Turkish navy has ships with 12 inches of armour and 9 inches of armour. The French have nothing afloat with more than $8\frac{1}{2}$ inches and 21-ton guns; but they have vessels building with 15 inches and 12 inches armour and 21 and 35-ton guns. The Italians have two enormously powerful ships building, the *Duilio* and *Dandalo*, which are to carry guns of 100 tons and armour of from 22 inches to 16 inches, we believe, on various parts.

Probably, then, when the *Inflexible* comes into the service with armour of from 24 to 18 inches, and 80-ton guns, she will find two Italian ships whose guns ought to be more than a match for hers, and whose armour is but little inferior. Until trials take place with 100-ton guns, we are not in a position to

speak of them; but, being made by Sir W. Armstrong, they will presumably be the same class of gun as the 80-ton, but more powerful in proportion to their increased size. It is to be presumed from the trials that have taken place that the 80-ton gun may not fall short of expectation, and may prove able to pierce 20 inches of armour up to about 1,000 yards range. It ought, therefore, under favourable circumstances, to be capable of piercing the sides even of the *Duilio* and *Dandalo* at short ranges; the question is whether the latter could hold off so as to increase the range so much as to retain the power of penetrating even the thicker sides of the *Inflexible* with the 100-ton guns, while the distance was such as to save her own thinner armour from the 80-ton guns of the *Inflexible*. This would be a difficult matter, for the larger the gun and projectile, the less any increase of range tells against the velocity of the shot; so that even where it was practicable to secure the desired range, it is greatly to be questioned whether the gun could be made to hit the desired object. The uncertainties are greatly complicated by the fact that a vessel which could present her plates at an oblique angle to the blow of an enemy would obtain a great advantage. Of the other vessels afloat, the *Great Peter* might be looked upon as the most formidable. Of her 40-ton guns we can only judge at present by comparison with our own 35-ton guns, for the 38 has never been tried against plates. Now the 35-ton gun has just got the head of its shot through a target which had as much as 17 inches of iron, besides skin and backing, at 70 yards range. But this target has always been considered by the Admiralty and other authorities an imperfect one; its plates were divided into three thicknesses, and altogether it is more than questionable whether the 40-ton gun could get through the *Inflexible* at her weakest place, even at the shortest range. Probably the *Inflexible* would be invulnerable to every foreign ship afloat, except the two Italian ones; and that she could pierce the sides of all except these at any range likely to be desired, there can scarcely be a question. We have, then, the case before us of three ships coming into the arena of naval warfare, who, even at this stage of development of guns and armour, stand in almost the same relationship to all ironclads previously afloat as they in their turn bore to wooden ships. The question raised by such a sudden increase in power as we naturally connect with the 80-ton gun is this: Are we proving the possibility of the construction of armaments on such a scale that there is no definite limit not only to the power to which guns and armour may eventually be brought, but to the augmentation that may *suddenly* be made in them? If, for example, the success of the 80-ton gun is only to be regarded as an illustration of the proof of the declaration that a gun of 200 tons could

be made, and armour of 20 inches proves that armour of 36 inches could be provided, it appears that it lies in the power of any nation, who will pay the required price, to construct an invulnerable vessel that might destroy everything at present afloat by means of her artillery. The rapid development of armour, at all events, favours the use of torpedoes and other means of attack below the water line, and the shape that naval warfare may at any future time assume seems more uncertain than ever.*

* The blocks employed in printing the plate have been kindly lent by the publisher of the "Engineer" newspaper.

AQUARIA: THEIR PRESENT, PAST, AND FUTURE.

By WILLIAM ALFORD LLOYD,

Manager of the Crystal Palace Aquarium.

EIGHTY-SIX years ago—in the year 1790—there might have been seen trudging along the streets of Edinburgh an "old blue-coated serving-man," carrying an earthenware pitcher or jar, of three or four gallons capacity. That pitcher contained sea-water for the marine aquarium of Sir John Graham Dalyell, Bart., who thus employed a man, or probably a succession of men, from the time he began aquarium-keeping till he finished at his death in 1851—a period of sixty-one years. The jar was sent to the sea to be filled twice or thrice weekly; but averaging it at five times a fortnight, and allowing four miles for each double journey from Great King Street to the sea and back, that amounted to 39,650 miles from the year 1790 to the year 1850, which was an enormous and perfectly needless expenditure of force, expressed in time and money, even although the results of Sir John's investigations were given to the world in five such important quarto volumes as his "Rare and Remarkable Animals of Scotland," 1847-8; and his "Powers of the Creator displayed in the Creation," 1851-8.

Dalyell's mode of operation, as told to me by his sister Elizabeth, in two letters dated 1860, and printed in the "Zoologist" of Nov. 1873, vol. viii. Second Series, pp. 3757-8, was as follows:—He kept his living marine animals, consisting of the lower kinds below fishes, in a number of glass cylindrical jars, of various sizes and proportions, and with usually one animal in each. The water in these jars he changed every morning, "often twice a day, if he perceived the smallest fragment amongst it, wiping and washing the glasses very clean." He then threw away the water so used, and replenished it from the earthenware jar with the water got from the sea. At one time I should not have termed this aquarium-keeping at all, because of

the change of water. (See "Crystal Palace Aquarium Handbook," 1875, p. 7.) But now, having got to think more broadly, I recognise this, not as a change of water in the sense of its being lost, but merely as a change of position from a house in Edinburgh to the sea, and back again. That is to say, the water he dismissed from his jars went into a gutter in a street, or into a sewer below it, and found its way by gravitation into the ocean again. Or, if it were poured on the ground into which it soaked, it found its way back to the sea by an infinitely more circuitous route. But, had Dalyell been more of a general philosophical thinker as well as a naturalist, he would have saved himself this very great amount of cost and trouble. Had he but reflected on that which was then known, namely, that water—both sea-water and fresh water—is practically indestructible, and that any decaying organic matter, animal or vegetable, or both mixed, can be got rid of, and the water be left pure, then he would have saved his servants their weary walks of more than as far, in their aggregation, as twice round the world, nearly.

In the ocean of course various animals and plants are incessantly dying in large numbers, and their decomposing remains are prevented from permanently poisoning the water in which other animals live and breathe, by the incessant motion to which the sea is subjected, and this motion brings the water into purifying contact with the atmospheric air which everywhere exists. It is this air, or rather the oxygen in it, which the water takes up in greater quantity than the nitrogen, which is another and larger component of the atmosphere, which is the source of purification alluded to, the water being merely a medium or a vehicle for the exhibition of the oxygen. In addition to this, vegetation grows by the action of light, and decomposes the poisonous carbonic acid gas evolved by the breathing of animals, the carbon being used to form the woody substance of the plants, and the residual oxygen being liberated for the use and benefit of the animals. Thus the ocean, and rivers, and lakes, and all other waters in nature, of varying degrees of freshness and saltness, by motion and vegetation, both originating from the sun, are maintained sufficiently pure and respirable.

These operations were going on almost at Dalyell's door, yet he did not learn to apply them to practice, as he might have done. What he did was this: He fed the animals in his jars on mussel flesh, which is easily diffusible in water, and which quickly makes it milky; and this, with the absence of growing vegetation, and the breathing and other emanations of the animals, soon caused the water to become offensive in appearance and in smell. So he threw it away. But the very act of

pouring it, and the motion of it as it trickled onwards to the sea, purified it, because such an act was an unconscious imitation of what nature does. Had Sir John but thought of the merely vehicular character of water, and of its incapability of being decomposed save by a very slow and expensive process, he would at once have seen that the minutely disseminated mussel flesh and its juices in the water made that water unfit to support life, only temporarily. It was not the water itself that was not fit; it was only something in the water that was wrong, and if that something were removed the water would be left as good as ever. If, therefore, instead of sending it back into the sea by a long road, and then going to the immense pains to dip it back again, he had poured it into a large receptacle in his own house, such receptacle or reservoir being many times larger than the aggregate contents of all his glass jars, he would have found that in a short time he would have possessed a source of supply for the jars quite as good as the ocean provided. Had he, in addition, placed his reservoir in a cool cellar, and had a pipe connecting it with the study to which Miss Dalyell has incidentally alluded, with a funnel at the upper end of the pipe, in which was placed a piece of straining-cloth or a small hair-sieve, to arrest the coarser pieces of decaying organisms, and if he had poured the water he had used into this funnel, the arrangement would have been still better. Yet better would it have been had he possessed another pipe leading upwards from the reservoir, through which he could pump up the sea-water as he wanted it. Best of all would have been some form of incessantly-working machinery, by means of which the water would be always coming up day and night from this large and cool reservoir into the experimental glasses, for then they would have been constantly kept at an even temperature and in a state of constant aeration. This would have done away with the necessity of the everlasting wiping and washing of the glasses; and, they being thus left alone, and in a certain amount of daylight, vegetation would soon have appeared in them, stimulated by the action of that light, without having been visibly introduced, but present everywhere in the seeds or spores of plants, merely waiting to be developed. Such an arrangement, indeed, would have been precisely that of the best modern aquaria as now made, in which the water is so continually and abundantly aerated by ceaselessly moving machinery, that impurities have no time to accumulate, but are oxygenated and dissipated as quickly as they form. In the Brighton and Havre public aquaria, the old and intermittent system used by Dalyell has been reverted to, and of course with ill results, as the water freshly obtained from the sea is turbid when seen in large masses, and is unhealthy for

the animals, only a small number of which therefore can be kept in great bulks of fluid, because it is insufficiently aerated. This will be the case also at the Scarborough aquarium, now being built on the same erroneous principle.

Dalyell, however, was no mechanician or physicist, and he knew nothing of marine botany; so he just did as his neighbours did with their fresh-water gold-fish globes—he changed the sea-water and threw it away as quickly as it became sullied, and this water he obtained at no great cost, he living close to the sea. Or if the cost of time in getting it was considerable in proportion to the work done, *i.e.* the quantity obtained, it mattered not much to him, as he was a rich man. Yet, had he but known it, the sea-water he thus obtained was less good for the animals he kept than it should have been, inasmuch that it was from the adjoining Firth of Forth, and of the density of but 1·024, at a temperature of 60° F.; whereas had he kept it for some months, it would have evaporated to the more proper density of 1·027 at 60° F., taking distilled water as being 1·000 at 60° F.

I have given this narration as showing the state of things aquarially at the end of the last century, and during the first half of the present one, and also as being the mode of operation which the general public, and even the great mass of the higher and better educated classes of society, still believe to be the system necessary to be followed in the maintenance of aquaria.

In the year 1842 the late Dr. N. B. Ward published the first edition of his book, in 8vo., on the growth of plants in closely glazed cases, and this in 1854 was followed by the second edition, in 12mo. In 1853 Dr. N. B. Ward's son, the present Dr. Stephen H. Ward, gave a lecture on this subject at the Royal Institution, which was published as a 12mo. pamphlet in the same year. All three of these are now and have been long out of print, and they bear testimony, indubitably, that N. B. Ward experimented with aquaria about the year 1840, though he did not use the word "Aquarium," which was employed for the first time in print, as far as I know, twice by Mr. P. H. Gosse, in his "Devonshire Coast," post 8vo., 1853, at pages 234 and 441. That is to say, N. B. Ward is the earliest recorded person who *intentionally* arranged together certain animals and plants in water, so that these two sets of organisms should mutually and partly support each other, the plants giving off oxygen and taking up carbon, and the animals taking up oxygen and giving off carbon, thus decomposing and rendering harmless the carbonic acid gas as continually as it was evolved by the animals, and maintaining the water pure. In Dr. S. H. Ward's pamphlet, just named, is a long, circumstantial, and most interesting narrative of how Mrs. Anne

Thynne did the same thing precisely with sea-water and marine animals and plants. This lady being in London in the year 1846, and having some living corals and sponges, used to send occasionally to the coast for supplies of water for her creatures. But finding that if a quantity of this water were taken up in a jug and let fall again from its spout in a slender stream, it lost whatever impurity it contained from contact with air in this much comminuted state, she ceased to get more from the sea, and instead got from thence some living seaweed and placed it in the water, which derived additional benefit from this vegetation, just as Dr. N. B. Ward found his fresh water had benefited by the plants he introduced. It is more than probable, however, that in both these instances the really beneficial vegetation was not that which was thus visibly introduced, but was the minute kind which grew parasitically on the plants and upon the inside of the vessels. Yet it must be admitted that this gentleman and this lady are the two first known persons who, keeping a chemical law in view, deliberately and purposely set about attaining means for its fulfilment in an aquarium.

In 1849 the late Mr. Robert Warington, chemist to the Company of Apothecaries, set up in his rooms, in the Hall of that Company, in London, his first aquarium, a fresh-water one, followed, in 1851–2, by his first marine aquarium. These he described in the periodicals of the day, and in a lecture which he also gave at the Royal Institution in an interesting manner, and naturally from a chemist's point of view. At about the same period Mr. P. H. Gosse commenced his earliest marine aquarium, as did Dr. J. S. Bowerbank, Dr. Cotton, and the late Dr. E. Lankester, and the successes attained by these experimenters induced the Zoological Society of London to determine to have a public aquarium in its gardens in Regent's Park. The building for this purpose was erected in the spring and summer of the year 1852. The marine and fresh-water animals were begun to be introduced in the late autumn; the following winter and spring were wisely spent in experimenting on the best modes of operating, and the exhibition was opened on May 21, 1853. After having been noticed in print by the "Athenæum" of some months earlier, it was again commented upon by that journal of May 28, and by the "Illustrated London News" of the same day and year, the latter publication giving views of two tanks. One of the earliest services which this institution conferred on biological literature may be seen in portions of the Natural History division of the "English Cyclopædia" (an adaptation of the earlier "Penny Cyclopædia"), as the former publication appeared fortnightly, commencing in the spring of 1853; and as it was edited by Dr. E. Lankester, who always took much interest in aquaria, he mentions in the book

from time to time that such and such animals named had been kept in this Regent's Park aquarium, to which he gave the needlessly long name of "Aquavivarium." This place was my own much loved and earliest place of Natural History studies, and in August 1853, I, too, arranged a little domestic aquarium of my own—a fresh-water one. Later, in the same year, I set up a small marine one, or rather a series of little aquaria in glass jars, holding from half-a-pint to a pint each. Seldom has a student begun with such very small means as I then possessed, for my sea-water was compounded of salts purchased at a London chemist's shop, and my animals were such little sea-anemones as I could find uninjured on oyster shells thrown into London streets. I was in earnest, however, and the difficulties I was so closely beset with, and they alone, enabled me to gain subsequent success. In the earlier books on aquaria—notably in Mr. Gosse's two volumes, his "Devonshire Coast" and his "Aquarium" (the latter having gone through two editions, 1853 and 1856, besides a recent reprint without the plates, which have been accidentally destroyed)—aquaria are associated in idea with conservatories, especially as to the growth of plants in each. This notion was very natural. Accordingly the Regent's Park aquarium was made virtually as a conservatory. But it was a diametrically wrong notion, as the first summer proved; and the second summer (1854) showed this still more conclusively; and the third (1855) yet more so, the evil being an accumulating one. It was then remembered, when too late, that marine and fresh-water plants and animals live in seas and rivers, where the temperature is much more restricted in range than that which obtains in the atmosphere.

It was seen that success was to be attained by representing these conditions of nature just named, and that to place such organisms in a glass house, where the rays of a summer's sun heated a mass of imprisoned air, was to kill the animals and to stimulate the plants to unnatural growth, or rather to cause them and some of the animals to be covered with a parasitic growth of the lower green algæ which obscured them. The errors of this earliest aquarium were strikingly shown by its solitary merit, the latter being its fresh-water division, occupying one side of the building, where the water coursed through the tanks in a constant stream, it being clear and cool, and peopled with an adequate number of healthy animals; while on the other side of the building, and in its centre, were the marine tanks, in which the water was, and still is, turbid and warm, and sparsely inhabited by not healthy creatures.

These good results were, however, obtained by accident and not design. The society possessed already a steam-engine, which pumped up water for the general use of its gardens,

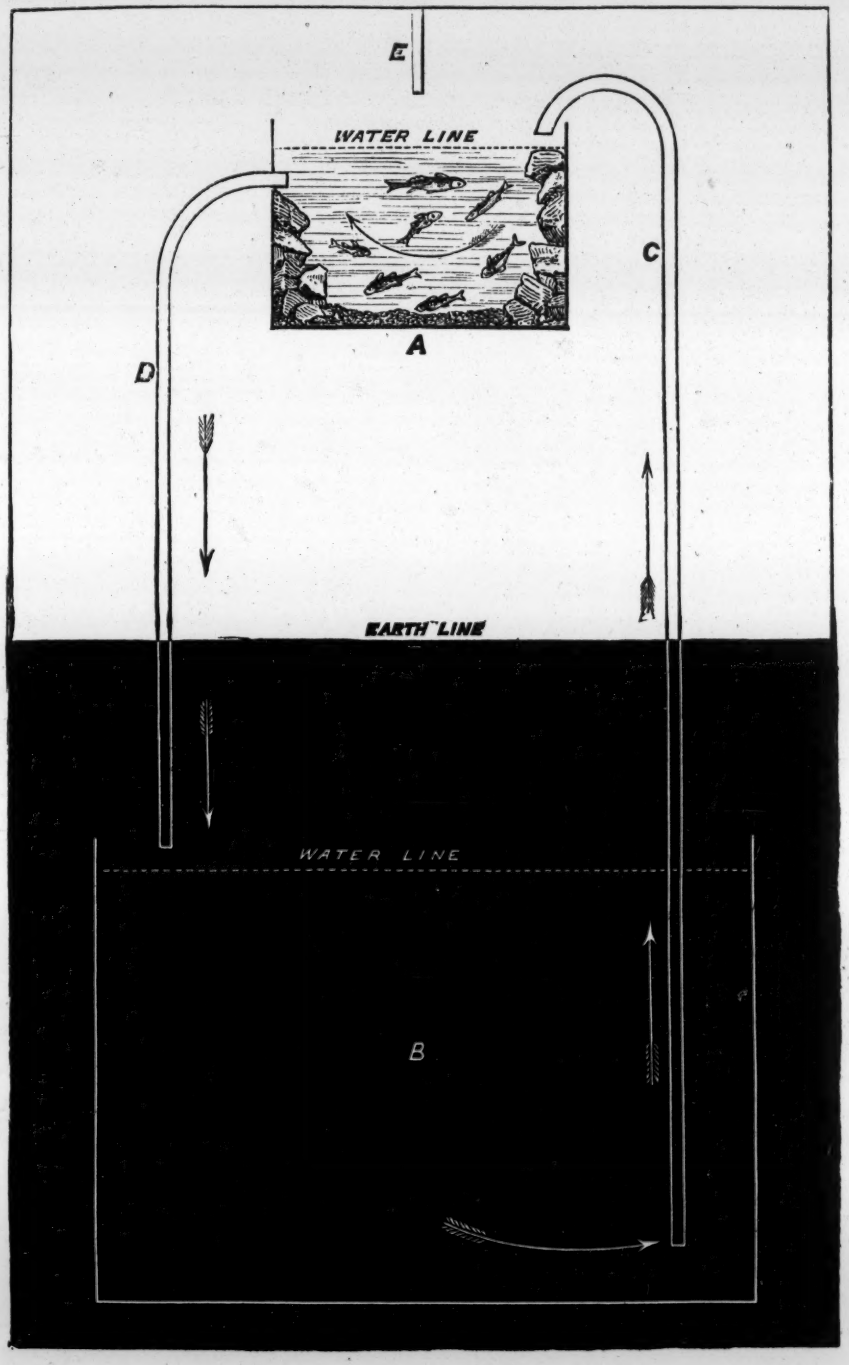
and it was a mere matter of course to connect the aquarium with this engine, and allow the water (which *chanced* to be drawn from a pure source) to run through the fish tanks, and then be applied to ordinary purposes, drinking or other, for which its passage through the tanks in no way unfitted it. I reasoned with the society that if the sea-water tanks were similarly treated on some such system as the fresh-water series, a correspondingly good result would be attained; and I pointed out that the same law governed both, because in the centre of the building were some isolated fresh-water tanks having no stream in them, and these were in a similarly ill condition as the marine tanks by their side. In reply, the society answered that a circulatory system did exist in a part of the sea-water series, but that it was almost useless; and I then pointed out that that was because the reservoir into which the sea-water entered after it had run through the show-tanks was too small in relation to the dimensions of the latter, and that the reservoir should be several times greater than the show-tanks. My reasoning was all in vain, however, for the society went on throwing away the sea-water when it was only *temporarily* unfitted for use, and getting at a cost of several hundreds of pounds yearly a weekly supply from the sea, especially when soon afterwards another evil made its appearance, consisting of a greenish-brown dense opacity permeating the water, and quite hiding from view all it contained. This was caused by excess of light, for I found that darkness removed it and made the water clear again; and this led to Mr. E. Edwards's invention of the dark-chambered tank, a modification of which is now, or should be, employed in all public aquaria where adequate results are aimed at and attained. So, at this early period, 1853-62, though in theory the Zoological Society of London, and everyone else who maintained aquaria, used the same unchanged water, especially sea-water, yet most persons sent to the sea, or to dealers, of which I was then one, for occasional new supplies. However, from 1853 to 1855, when I could not possibly get new sea-water for my little jars, I merely increased the quantity of water to about eight or ten times as much as those jars collectively held. Thus the aggregate contents of my jars were about six or eight pints; and in a now historical earthenware foot-pan, kept dark in a cool corner at hand, I had five or six gallons more water, containing neither animals nor plants, and when aught occurred to disturb the equilibrium of life in these jars, either from excess of light or heat by standing on a light window-sill, or from excess of food, or from there being too many animals in a small space, instead of throwing away the water thus *temporarily* rendered unfit to sustain life, I merely restored it to a right condition by pouring the contents of these jars into the

foot-pan, which was so large in relation to the dimensions of the jars, that I could immediately dip them up full from it (the foot-pan) without the water being perceptibly the worse for it, especially when I so contrived matters that these transfers were made, not in one day, but on successive days. Thus, in London, far from the sea, which I had never seen, I was, so far, aquarially speaking, as well off as the wealthy Sir John Graham Dalyell, with the ocean almost at his door. Later on, in 1857–8, I set up another marine aquarium, in which the show-tank held 20 gallons, and the reservoir 500 gallons, of water, in which that water, instead of being intermittently circulating, as in my jar and foot-pan arrangement, circulated constantly, day and night, by means of a pump and pipes, in a cool underground London cellar or kitchen, with a uniform temperature of about 60° F. This answered excellently, especially when I increased the water in the reservoir to 1,000 gallons.

In 1860 I arranged in the Paris Acclimatation Gardens an aquarium which had been incipiently planned, or rather contemplated, by Mr. D. W. Mitchell, who had died some months before then, and I made the circulation a constant one, and gave as large an underground reservoir as funds would allow, but which was insufficient. In 1862 I went to Hamburg, where, with the aid of the late Mr. A. Lienau, an engineer of great knowledge, who saw the advantage of a large reservoir, I made the aquarium in the Zoological Gardens there, which was opened in 1864; and it was under my management so successful that it called other continental aquaria into existence, but not with so great a success, because of neglect in having the machinery so good, and the reservoirs so large, as they should be. But commercial companies, anxious for money success, and for that only, frequently fail from inattention to proper construction, and especially to hidden constructions which the public never see. In 1870 I returned to England, and, with Mr. C. H. Driver, arranged the Crystal Palace aquarium, with further improvements in machinery, and a still relatively greater reservoir. This, too, has been and is so very successful that I have been called upon to supervise the construction of several other public aquaria in Britain and abroad; and to perpetuate my modes of operation, both in construction and management, I now take pupils, who, when called upon, are ready to undertake the curatorship of aquaria in a scientific manner.

On March 1 last, Mr. W. S. Kent delivered a lecture in the rooms of the Society of Arts, the chief aim of which was to show that not large but (relatively to show-tanks) small reservoirs are necessary, or even no reservoirs at all. This is printed in the "Journal of the Society of Arts" of March 3 last, and my unanswerable reply to it may be seen in the

same journal of March 24 last. If it be urged that small reservoirs may be made to do as makeshifts, because money and space for them cannot be afforded, there is some kind



of reason in *that*. But if it be averred to the contrary *as a principle*, then that indicates a singular amount of no knowledge which, if possible, is something more than won-

derful. My arguments are founded on the clear and simple obviousness of the fact that a given quantity of dead organic matter diffused through a large quantity of water sullies it less than if it were small, and on the necessity of maintaining an evenly moderate temperature for the reasons already given, avoiding the high and low ranges of the atmosphere; and I show that the easiest manner of attaining this is by having a large reservoir sunk in the earth at a distance giving a known temperature. Thus, referring to the sunk thermometers at the Greenwich Observatory, with a thermometer having its bulb on a level with the scales of the sunk instruments, the lowest (January) mean monthly reading in a named year was 36·4° F., with a mean daily range of 6·9° F.; and under the same circumstances the highest (July) mean monthly reading was 66·9° F., with a mean daily range of 19·9° F. But from the showing of other thermometers whose bulbs are sunk in the ground to the respective depths of one inch, three feet, twelve feet, and twenty-five feet, the temperatures become strikingly even for the whole year through—so much so, that at twenty-five feet deep the mean monthly reading of January was 52° F., with a mean daily range of only 0·025° F.; and the mean monthly reading of July was 49·0° F., with a mean daily range of but 0·06° F., the highest mean daily range at that depth in any month of the year being 0·07° F. in August. To apply this to aquaria, I have made the accompanying diagram (p. 261), it being an ideal vertical section of an aquarium, consisting of a show-tank A, with its reservoir B in the earth, with an inlet supply-pipe C, and an outlet pipe D, the six arrows showing the direction of flow of water. E is a pipe supplying water to compensate for evaporation, which, both for marine and fresh-water aquaria, should be distilled water. For simplicity, the engines, pumps, &c., which circulate the water are omitted, the showing of results being alone aimed at.

Supposing that in any part of an English year the temperature of B would be 60° F., and that in summer A would rise to 75° F., that would be much too warm for an aquarium containing British animals. Or it might in winter sink to 30° F. or less, that would be much too cold. But on a sufficient circulation being established between A and B, then their mean temperatures would be expressed by the seven following formulas, varying according to the size of B:—

Formula No.	1.	A 2	.	B 1	.	Mean result	70° F.
,, ,,	2.	A 1	.	B 1	.	,, ,,	67·5° F.
,, ,,	3.	A 1	.	B 2	.	,, ,,	65° F.
,, ,,	4.	A 1	.	B 3	.	,, ,,	63·7° F.

Formula No. 5.	A 1	.	B 4	.	Mean result	63° F.
„ „ 6.	A 1	.	B 5	.	„ „	62·5° F.
„ „ 7.	A 1	.	B 20	.	„ „	60·7° F.*

Indeed if B were one hundred times as large as A, and were kept at 50° F., then A might be in an atmosphere at 212° F. (the heat of boiling water), and yet its water would be only 52·12° F., and the most delicate English animals would live in it. At Nottingham is an aquariam where the show-tank and reservoir spaces have had to be made as 13 is to 1. From Bünsen's tables in his "Gasometry," page 288, may be ascertained the amount of atmospheric air which water in open vessels will absorb at given temperatures, the barometer being at 39″; and I here reproduce his figures, having converted his Centigrade scale into Fahrenheit and Reaumur scale for the benefit of English, German, and Spanish readers.

Bulk of water = 1·

Temperature. C.	R.	F.	Air absorbed.	Temperature. C.	R.	F.	Air absorbed.
10 =	8 =	50 .	0·0195	16 =	12·8 =	60·8 .	0·0177
11 =	8·8 =	51·8 .	0·0192	17 =	13·6 =	62·6 .	0·0175
12 =	9·6 =	53·6 .	0·0188	18 =	14·4 =	64·4 .	0·0173
13 =	10·4 =	55·4 .	0·0185	19 =	15·2 =	66·8 .	0·0172
14 =	11·2 =	57·2 .	0·0182	20 =	16· =	68 .	0·0170
15 =	12 =	59 .	0·0180				

And therefore as the more air there is in the water the better it is, hence the value of large and therefore cool reservoirs. Inpedendently of all this, however, the larger the bulk of water, and the more constant and vigorous the circulation and aeration, the less it will be sullied by the animals which live in it. In the Crystal Palace Aquárium we have in the show-tanks 20,000 gallons of sea-water, and in the reservoir 100,000 gallons, total 120,000 gallons, supplied by Mr. W. Hudson in 1870. Yet in this comparatively small quantity of unchanged fluid we have, from Sept. 1871 to March 31, 1876 (four and a half years), given to the animals in it the following enormous quantity of food without the water being otherwise than always sparklingly clear:—

* The water in the Crystal Palace aquarium has a very small range of from 52° F. in very cold, to 61° F. in very hot, weather. In April last (1876) we had, at Sydenham, blue skies, a bright sun, and an oppressive warmth, with 74° F. in the shade, on the 8th of the month. On the 12th, four days after, we had a leaden firmament, and clouds of blinding snow and sleet driven by a bitter north-east wind, with the thermometer at 29° F., giving so great a range as 45° F. within a week. Yet the water in the aquarium had a range of only 1° F. = 54° F. to 53° F.

1.	Sandhoppers (*Talitrus*), in pounds weight	12
2.	Shrimps (*Crangon*), in quarts	4735
3.	Crabs (*Carcinus*) in gallons	137
	„ (*Cancer*), large „ numbers	1450
4.	Scallops (*Pecten*) large, in numbers	32
5.	Oysters (*Ostrea*) „ „	2195
6.	Cockles (*Cardium*), in gallons	18
7.	Mussels (*Mytilus*) „	3544
8.	Whelks (*Buccinum*) in gallons	7
	„ numbers	100
9.	Fish, chiefly Whiting (*Gadus*), in pounds weight	3159
10.	Smelts' roe (*Osmerus*) „ „	14
11.	Green seaweed (*Ulva*), purchased „	400
12.	„ „ (*Conferva*), grown in tanks, quantity unknown.	

And, in addition, we obtain occasional and unrecorded supplies from neighbouring fishmongers when the regular supply runs short. Of this animal food, all but the denominations 9 and 10 are kept alive in a series of reserve tanks till the moment of being eaten. Scarcely any uneaten food, and never any excrement, is manually removed; but all which is not consumed by the animals is chemically dissipated, without filtering, by the enormous volumes of air constantly being injected into every tank by Leete Edwards and Norman's machinery, the speed of which is accelerated (*i.e.* the oxygenation is quickened) when the water is slightly turbid from an excess of organic matter. All this I have explained more at length in the "Official Handbook to the Crystal Palace Aquarium," and in "Observations on Public Aquaria," both published at the Crystal Palace. It is this power of oxygenating, or consuming, or burning, at a low temperature, termed by Baron Liebig "eremacausis,"* which expresses the real work done in an aquarium, and the force necessary to do that work. Even our thick beds of sand and shingle at the bottoms of each tank are so fully charged with air, that one thrust of a stick will release a pint of it in bubbles. This is a source of purification and health quite unknown till recently. Consequently the floors of our tanks (excepting the sea anemone tanks) are as speckless and as free from the blackness caused by sulphuretted and carburetted hydrogen gas, as on the day they were laid down in 1870. If we have an excessive growth of seaweeds anywhere, we turn in a shoal of grey mullet (*Mugil capito*), who nibble it down close, like sheep in a field of grass. This leads me to say that at present we do not know how to grow the higher marine algæ, the red, the brown, or even the

* From the Greek "to remove by burning, or by fire." The words "caustic" and "cautery" have the same derivation.

green kinds, at will. Sometimes I succeed, but always by chance, not knowing why.

Of the general influence of aquaria on Zoology we have curious evidence in Mr. Gosse's most excellent "Manual of Marine Zoology for the British Isles," published in two volumes, in 1855–1856, in which the author enumerates 1,785 species, from sponges to fishes, and of which he figures 779 genera, always preferring to draw from living animals whenever possible. Now, as at that period a larger number of aquarium animals had passed through his hands than through those of any other person, he may be presumed to have, up to then, seen more of them alive than anyone else. Yet he enumerates only 201 as having been drawn from life, as he avowedly preferred doing, and of these but a dozen were fishes, others being, for the most part, small creatures, or those which are easily maintained, and do not need large tanks and elaborate machinery. But, during the twenty years which have elapsed since 1856, I have seen and handled, and had under my care, in England, France, and Germany, about 433 species of British marine animals, of which 112 were fishes.

There are few things more trying to that great virtue—patience—than a large public aquarium, especially in its preparation, before it is ready for the reception of animals. It is to this lack of patience on the part of the directors of the Royal Westminster Aquarium, and to their absolute refusal to allow me to have proper engineering assistance during its construction, and to general mismanagement, that its present confused state, and its unsatisfactory condition in every way, is due. On this account, I resigned my post of adviser to the society, as I found it useless to advise when advice was recklessly disregarded. Aquarium work, being hydraulic engineering on a small scale, is essentially the work of an engineer, and not that of an architect, unless he is also an engineer and a mathematician. There is for aquaria a great and important future, both as regards their influence on science, and as pecuniary speculations, if indeed, as I much doubt, there can be any real severing of these two interests. Success, however, must always be the result of a careful study and representation of what nature does, and of a strict avoidance of the recent heresies to which I have in this communication adverted.

POPOFFKAS, OR CIRCULAR IRONCLADS.

By A. HILLIARD ATTERIDGE.

SPEAKING at Nicholaiev in May 1875, before an audience chiefly composed of officers of the imperial navy, Admiral Popoff briefly but clearly set forth the principles which have guided the Russian Government in the reorganisation of its navy since the Crimean War. The resources of Russia, he said, did not permit her to undertake the construction of an offensive navy—a fleet of huge line-of-battle ships. It was therefore decided that the object to be held in view should be the formation of a strong defensive fleet, so powerful as to be able to protect the coasts of Russia from any possible coalition, and in 1871 he submitted to the Admiralty at St. Petersburg designs for what he suggested should be the typical form for the ships constructed for the coast defence of the empire. Admiral Krabbé approved of the project; the ship was laid down at Nicholaiev, the great naval arsenal of Russia on the Black Sea; and three years after the *Novgorod*, the first circular ironclad, was launched upon the Boug; and a few months later, fully armed and equipped, steamed down the river to the Black Sea, and made a successful voyage to Sebastopol. A second ship, originally called the *Kiev*, but named on launching the *Admiral Popoff*, in honour of her inventor, was begun and completed shortly after the *Novgorod*; and these two circular ships now form the principal strength of the Black Sea fleet.

Mr. Reed, the late chief constructor of the British navy, from the first urged the consideration of the structure of these new vessels upon public attention in England. They were avowedly a further development of the principle which he had adopted in shortening the length and broadening the beam in the later ironclads which he designed for our navy. He saw the keels of the *Novgorod* laid at Nicholaiev; in "Naval Science" he devoted several articles to the new ships, and published the first drawings of them which appeared in England. Last autumn he went to the Black Sea, made a voyage in one of the

Popoffkas, and described her performances in the remarkable letters to the "Times," which at length attracted general attention to the subject; and then, on Feb. 4, he gave a full account of the circular ironclads in a paper read before the Royal United Service Institution, in which he spoke of the introduction of this new type of man-of-war into a European navy as marking the beginning of a revolution in naval architecture. The Popoffka was originally designed only for coast defence; but Mr. Reed would have us make such vessels, with or without certain modifications, the type of the line-of-battle ship of the future. We propose to review the subject here; but, as the Popoffkas have been so fully and so recently described, we need not enter into the details of their construction at any great length.

The Popoffka is, roughly speaking, a saucer-shaped ship. With the exception of a slight projection at the stern, the ship is in outline a perfect circle. The deck is about 18 inches above the water, but curves upwards towards the centre to a height of about 4 feet. The bottom is flat, with several parallel keels, but its diameter is much less than that of the deck, and the side curves upwards, any section of it being a quadrant of a circle whose radius is equal to the depth of the ship. In the centre of the deck is what has been called a fixed turret, but it is really an open breastwork over which two heavy guns fire *en barbette*. The deck, the breastwork, and the sides of the ship, are all armoured. In front of the breastwork, at what is called the bow of the vessel, there is a lightly-built forecastle, and before this hang the anchors, the cables passing into it through hawse-holes, and thence to the chain-lockers. The two funnels are placed amidships, one on each side of the deck. There are six engines, each driving a screw, the six screws being arranged three on each side of the rudder along the sternward part of the circumference, the screws working independently, and the shafts being laid parallel to each other and to the line from bow to stern. On each side of the diameter there are two boiler-rooms each containing four boilers. The engine and boiler-rooms and coal-bunkers occupy the sternward half of the ship. In the middle are the powder-magazines and the shot-and shell-rooms, and in the forepart are the chain-lockers, water-tanks, and store-rooms. Above these and in the forecastle are rooms for the crew, the officers' rooms being placed in the centre of the ship under the breastwork. A passage runs round the ship, another traverses her longitudinally, and these form the chief means of communication under the upper deck. The armour on the sides of the *Novgorod* is from 9 to 11 inches thick, including an allowance for the hollow iron girders filled with teak which form the backing. The

armour of the breastwork is 11 inches thick. The thickness of the side-armour of the *Admiral Popoff* is from 16 to 18 inches, the breastwork being protected with 18-inch armour. The armour is carried to a depth of 4½ feet below the water-line. In both vessels the curving deck is covered with armour 2¾ inches thick, this thickness being considered quite sufficient to resist shot which must necessarily strike at low angles, as the Popoffkas are not intended for the attack of fortresses. The two guns in the breastwork are mounted on a platform which revolves on a central upright axis; this axis is hollow, and in action the charges for the service of the guns are passed up through it. The recoil is regulated and stopped partly by hydraulic compressors, partly by wedges in the back part of the slides. In action or in stormy weather all apertures are closed except those within the breastwork. Through these the ventilation of the ship is kept up, the air currents being formed by revolving fans. A light rail runs round the deck, and there is a bridge aft of the breastwork and level with the top of it. The engine-room hatchway is under this bridge, and the combings are carried up to it, so that it is safe from being flooded by the sea, which, from the extremely low freeboard, must frequently break over the deck.

The principal dimensions of the two ships are as follows:—

	Novgorod		*Admiral Popoff*	
	Ft.	Ins.	Ft.	Ins.
Extreme diameter	101	0	121	0
Diameter of flat bottom	76	0	96	0
Depth of hold	13	9	14	0
Draught of water { forward	13	2	12	0
Draught of water { aft	13	2	14	0
Height of top of breastwork above the water-line	12	0	13	3
External diameter of breastwork	30	0	34	0
Displacement	2,490 tons.		3,550 tons.	

The nominal aggregate horse-power of the six engines is in the *Novgorod* 480, in the *Admiral Popoff* 640. But the actual indicated horse-power is very high, that of the *Novgorod* at full speed being 2,270. The capacity of the coal-bunkers is very small; the *Novgorod* can carry only 200 tons, the *Admiral Popoff* only 250. The former vessel has a crew of 110, the latter of 120 officers and men.

The highest speed ever attained by the *Novgorod* was 8½ knots, with an indicated horse-power of 2,270. Her ordinary speed is about 6½. These are important figures, for it is on these data that the whole question of the efficiency or non-efficiency of the Popoffka as a ship of war must depend. We

shall examine this question from two points of view—first, what is the value of the Popoffka as a vessel intended for coast defence in the shallow waters of the Black Sea, or the Sea of Azov; and secondly, is the Popoffka system applicable to vessels intended for ordinary warlike purposes and for naval operations in the open sea?

Now it must be quite evident that the *Novgorod* and the *Admiral Popoff* are not ships at all, but only floating batteries of novel construction. Even the maximum speed of $8\frac{1}{2}$ knots obtained by the *Novgorod* on a special occasion is a low one; lower still is her ordinary speed of $6\frac{1}{2}$ knots. Their coal supply is so small that they cannot cruise, but must simply use it to reach some station selected for defence, and then to work their ventilating fans and gun-platforms. The low circular hull is little better than a movable pontoon floating the breastwork and the guns. The Popoffka, if she sought an action, could not overtake the slowest ironclad in any European navy; or if she wished to avoid one, she could not escape. A hostile ship could choose her own position and distance in fighting her; and if an enemy chose to use his ram, the *Popoffka*, with her inferior speed, would find great difficulty in avoiding it, let her work her six screws as she would. The open turret or circular breastwork offers very little protection to the men working the guns. The two 28-ton guns of the *Novgorod* are mounted so as to fire *en barbette*—that is, over a breastwork which has no portholes—so that the men are continually more or less exposed to fire. The 40-ton guns of the *Admiral Popoff* are in a better position, for they are mounted on the disappearing principle; but in both ships the crews of the guns would be exposed to bursting shells; and in addition to this, in the *Novgorod* the men at the guns would suffer from showers of shrapnel-balls at long ranges and rifle fire at close quarters. Again, there is no overhang at the stern to protect the six screws. In fighting a single antagonist or defending a narrow channel, the *Popoffka* would, of course, protect her screws by keeping her bow to the enemy; but if she had to engage more than one hostile vessel, her whole motive power might be destroyed by a few well-directed shots.

It is easy enough to say that an overhang could be added to protect the screws, and that a closed turret could be substituted for the breastwork, but the mere fact that this has not been done by Admiral Popoff is enough to show that serious difficulties stood in the way of such an arrangement. And it is quite evident in what these difficulties consist. The ships have been built to carry thick armour and heavy guns on a light draught and small displacement. For this the circular form was adopted, and to this every other consideration was sacrificed.

Now the addition of the overhang and extra weights in the turret would have to be compensated by a decrease in the weight of armour and guns, or there would be an increase in the draught of water. Moreover, the adoption of the closed turret would have to be attended with numerous serious modifications in various structures on the deck. At present, by adopting the *barbette* arrangement, the only obstacles to an all-round fire are the two funnels, one on each side; and of course it is easy for the Popoffka to take such a position with respect to the object aimed at that the funnels are kept out of the line of fire. But if a closed turret were substituted for the breastwork, the guns would have to fire through portholes, and either the turret would have to be made much higher than the present breastwork, so as to have its ports 12 or 13 feet above the water, or the forecastle, the bridge, and the high combings of the engine-room hatchway, would have to be lowered or done away with altogether. Now this forecastle plays a very important part in the economy of the ship. It contains the chief quarters for the men, and it protects the upper deck from the immense bow-wave raised by the blunt circular bow as it is (so to say) forced violently through the water when the ship is under steam. "The forecastle," says Mr. Reed, "of course adds greatly to the buoyancy forward when the sea rises there upon the vessel, and I do not think even circular vessels of very low freeboard could be steamed against a heavy head-sea without such a forecastle, more especially, as we shall see hereafter, when driven at a high speed." The forecastle, then, and the other deckhouses, must be maintained; so that if we are to remove the badly protected open breastwork, and substitute a closed turret for it, that turret must be of great height, adding largely to the weight carried by the vessel, increasing her draught of water, and thus taking away from her one of her few advantages.

We have marked out the want of speed as the chief defect of the Popoffka system, and necessarily closely connected with this is the small coal-carrying power. A round ship could indeed be driven through the water at a high speed, and so could a square one for that matter; but this is not the point at all. The shape of a ship is, of course, one of the main elements in a question of speed; the others are her draught of water and the power of her engines. On her shape chiefly depends the amount of resistance offered by the water. Leaving the question of draught of water out of account, resistance is least in a ship built on such lines that her horizontal section at the water line generally corresponds to the wave lines formed by the water as it is parted by the bow and unites again astern. In the case of a short ship with a broad beam, like

many of our ironclads, when steaming at any high speed, for want of this correspondence of the lines of the ship and the natural course of the wave lines, the water is piled up round the bows, and forms the bow-wave which floods the forward portion of the decks of low freeboard ships like the *Devastation*. This bow-wave is a kind of visible index of the resistance of the water, and in the Popoffkas it increases to the enormous mass of water which in a rough sea rises on the ship and makes the high forecastle a positive necessity. The bow-wave is a matter of some importance viewed in this light, and Mr. Reed's joke about people being anxious that the water should not be knocked about by his shortened ships is little to the purpose; for the bow-wave simply means that the short-broad ship finds it more difficult to get through the water than her longer competitor, and the round Popoffka finds it most difficult of all. The circular shape, so to say, handicaps the engines; they must have a power out of all proportion to the speed obtained. To rise to a high rate of speed, the weight of engines, boilers, and fuel would have to be enormously increased, and the weight of guns and armour reduced in a corresponding degree, or else the draught of water would have to be augmented. And with the adoption of either alternative, the special object for which the Popoffkas were designed would have to be sacrificed. Little if anything would be gained by giving the ship a larger diameter, and thus increasing her floating power; for the greater the diameter the greater the resistance of the water, and consequently the more powerful and the heavier the engines that would be required. This increase of resistance with the increase of diameter is also the fatal objection to the proposal of a lightly-built outer ring to contain bunkers, which would supply the present deficiency in coal-carrying power.

This question of speed and engine-power is, we believe, the real test of the whole matter. Mr. Reed, of course, recognises the fact; and in his lecture or paper, read at the Royal United Service Institution, he endeavoured to prove that "the circular ironclads have started with a much less proportion of steam-power to citadel armour and guns than has usually been given to ironclads, and not with an enormously greater power." To our mind his facts and figures disprove his conclusion. He acknowledges that, "as compared with ordinary forms, the power required to drive at high speed a circular ship of equal displacement would probably be from two to three times that required for an equal displacement obtained on ordinary lines, or even more." But, he said, the displacement did not offer a true basis of comparison; such a basis was to be found in the proportion of steam power to the weight of guns and armour

carried. In other words, in the proportion of propelling power to the fighting power of the vessel propelled. With this we readily agree. Let us now examine Mr. Reed's figures, as given in the report of his lecture. He first took weight of guns and armour of the *Novgorod*, and the *Warrior*, and the *Defence*, which he selected as types of ordinary ironclads, and with this weight he compared the indicated horse-power at full speed. We give his tabulated results, merely adding to them the speed obtained:—

	Novgorod	*Warrior*	*Defence*
Weight of armour and guns protected .	806 tons	1,100 tns.	700 tns.
Indicated horse-power at full speed .	2,270	5,470	2,500
Proportion of power to weight driven .	2·8 to 1	4·9 to 1	3·5 to 1
Speed obtained	8½ knots	14·35 knots	11·6 knots

A little later on he made a similar comparison with the *Prince Consort*, the figures being:—

	Novgorod	*Prince Consort*
Weight of armour and guns protected .	806 tons	1,080 tons
Indicated horse-power at full speed .	2,270	4,234
Proportion of power to weight driven .	2·8 to 1	3 9 to 1
Speed obtained	8½ knots	13 knots

Here there is no real comparison. Mr. Reed should have taken, not the indicated horse-power of the *Warrior*, *Defence*, and *Prince Consort*, at full speed (that is, at from 12 to 14 knots), but their indicated horse-power at 8½ knots, the speed of the *Novgorod*. As everyone at all conversant with the subject knows, and as Mr. Reed himself has shown very clearly in his work on "Our Ironclad Ships," the indicated horse-power developed in obtaining the full speed of a ship is out of all proportion to that developed for a speed of even two knots lower, the indicated horse-power at 14 knots being often double that at 12 knots; a still greater difference would be apparent if we were to compare the indicated horse-power at rates of speed so different as 8½ and 14 or even 12 knots. Bearing this principle in mind, it is evident, even from Mr. Reed's figures, that the Popoffkas have been provided with engines relatively far more powerful than those of our fleet; and the ships Mr. Reed has chosen for comparison are some of the oldest of our ironclads, for the *Warrior* was launched in 1860, the *Defence* in 1861, and the *Prince Consort* in 1862. Why not select for this purpose some more modern vessel, with improved engines and a really heavy armament? We shall do this here with one of Mr. Reed's own ironclads, and following his method of investigation, but taking not only the full speed, but a lower speed also of the English ship; and we select for this purpose the *Hercules*, a ship designed by Mr. Reed, on the central battery

system, and launched in 1870. She is armed with 18-ton guns, and protected with 9-inch armour.

Let us take first the *Hercules*, at her full speed of between 14 and 15 knots, and compare her with the *Novgorod* :—

	Novgorod	*Hercules*
Weight of armour and guns protected	806 tons	1,534 tons
Indicated horse-power at full speed	2,270	8,529
Proportion of power to weight driven	2·8 to 1	5·5 to 1
Full speed obtained	8½ knots	14·691 knots

Here, if we were to leave the difference of speed out of account, it would seem that the proportionate engine-power of the *Novgorod* is only half that which is given to the *Hercules*, whereas really the proportion lies the other way, and the Popoffka has to employ engines relatively more powerful than those of the *Hercules* to obtain a much lower speed. This will be clear from a comparison with the *Hercules* going at a little more than 12 knots an hour, the first real comparison that we have had yet, for here is something like equality in at least one of the elements :—

	Novgorod	*Hercules*
Weight of armour and guns protected	806 tons	1,534 tons
Indicated horse-power	2,270	4,045
Proportion of power to weight driven	2·8 to 1	2·6 to 1
Speed obtained	8½ knots	12·123 knots

So that with a lower proportion of engine-power the *Hercules* obtains a speed more than 3½ knots higher than the full speed of the *Novgorod*. This, we think, clearly shows the fallacy of Mr. Reed's argument, drawn from the indicated horse-power at full speed of three of our oldest ironclads. We believe that these statistics of the performances of the engines of the *Hercules* at 12 and 14½ knots as compared with those of the *Novgorod* at 8½ knots, prove incontestably "that the circular ironclads have started with a much" *greater* "proportion of steam-power to citadel armour and guns than has usually been given to ironclads," the point which Mr. Reed endeavoured to disprove at the Royal United Service Institution on Feb. 4.

We arrive, then, at these conclusions. The Popoffkas, on account of their low rate of speed and small coal-carrying power, are necessarily adapted only for coast defence, and operations within very restricted distances from a port of departure. They can neither escape from, overtake, nor manœuvre against an enemy who has a high speed at his disposal. They have engines much more powerful than those given to ships built in the ordinary way, and a high speed cannot be given to them without an enormous increase of engine-

power, which would necessitate a deeper draught or a lighter armament. If the ship is made larger to make room for these heavy engines and the requisite boilers and coal-bunkers, there will necessarily be a corresponding increase in the difficulty of forcing the great curved bow through the water. The screws are unprotected, the men working the guns in the open breastwork are very imperfectly sheltered, and the structure of the Popoffka makes it difficult to substitute a closed turret. The ship, then, cannot cruise; and even for coast defence she is a very imperfect engine of war. For the latter purpose gunboats of the *Staunch* class would be equally, if not more, efficient. These gunboats are small, low, unarmoured vessels, carrying one gun in the bow. Being fought bow-on they present a very small mark to an enemy; and if the gun were mounted on the Moncrieff principle, the gunners would be at least as well protected as those who will man the open breastwork of the *Novgorod*. There would be no difficulty in mounting and fighting a gun of 35 tons or even more in a gunboat of the *Staunch* class; the 18-ton gun is the heaviest yet mounted in these gunboats in our navy; but Messrs. Armstrong are, we believe, now constructing for a foreign government one which will carry a 25-ton gun. These gunboats have twin-screws, the gun is pointed by means of the helm, and with a bow-rudder the gunboat can reverse her engines and run astern fighting her gun, and still keeping her propelling power protected by being turned away from the enemy. Additional protection for the engines could be secured by the use of one or more armoured bulkheads. We have thus already in our navy a good type of a small light-draught vessel for coast defence, and we do not see what further advantage is to be obtained by the adoption of the Popoffka system.

As for Mr. Reed's suggestion that we should adopt the Popoffka as a central citadel for a cruiser, with a lightly-built bow and stern added to it, it must be considered on quite a different basis. The system of an armoured central citadel with unarmoured ends has already been adopted in our navy, and very highly developed in the plan of the *Inflexible*, which we described in these pages in January last. There is no prohibitory reason why the central citadel should not be round instead of oblong, as in the *Hercules* and the *Inflexible*; but, for our part, we prefer the oblong form as affording more room and fitting more easily to the ordinary form of the ship. But such ships in any case would not be Popoffkas; and the real question with regard to them would be the old one of the relative merits of short-broad ships and ships of ordinary proportions—a question which we do not intend to discuss here. We have endeavoured to show that the Popoffka is practically a useless form in naval architecture. We have only touched upon a few points, but

these are sufficient. Certainly they are the most important, and we believe that they are the crucial tests of the efficiency or non-efficiency of the system. The whole subject is being experimentally investigated by Mr. Froude on the part of the Admiralty; and when his report is published we expect that the public will be in possession of a judgment upon the Russian circular ironclads very different from Mr. Reed's.

ON THE EXTINCT ANIMALS OF NORTH AMERICA.

By Professor WILLIAM HENRY FLOWER, F.R.S.

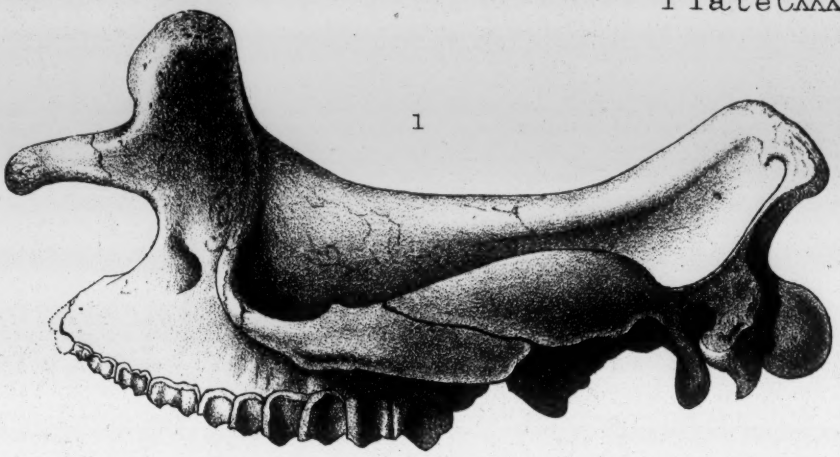
[PLATE CXXXVIII.]

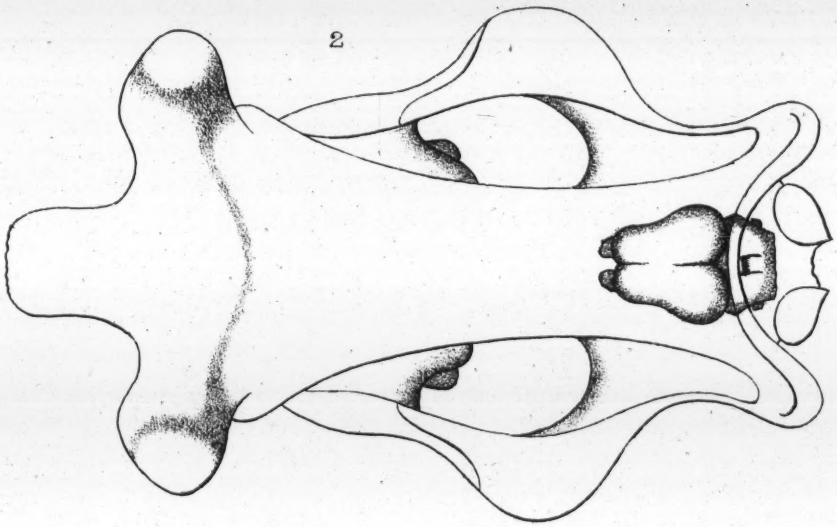
FEW branches of knowledge have received greater accessions during the last few years than that of the past history of the living creatures which have peopled the earth.

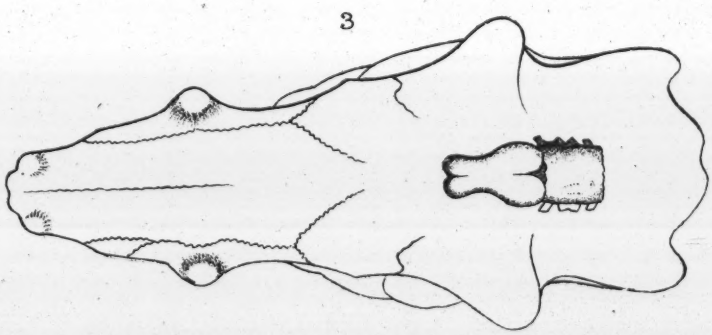
I propose in the present instance to call attention to some of the results that have been achieved, mostly within the last four or five years, by a small but energetic band of explorers upon a limited part of the earth's surface; results the greatness of which already is only equalled by the promise they give of future still more important extensions of knowledge.

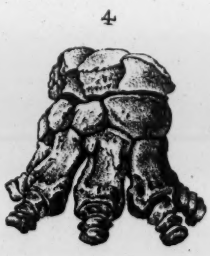
It is mainly through the agency of the admirably conducted geological and geographical surveys of the Western Territories, made by the United States Government, under the direction of Dr. F. V. Hayden, that the subjects to which I shall refer have been brought to light; surveys which are giving to the world, in an excellent series of publications, rich funds of information upon the physical geography, mineralogy, geology, palæontology, zoology, and botany of that hitherto little known but most remarkable region of the earth embracing and bordering the great range of the Rocky Mountains. For the special knowledge which we in England possess of the vertebrate fossils which have been discovered by these surveys, we are greatly indebted to the excellent descriptions of Professor Joseph Leidy of Philadelphia, who in two large and beautifully illustrated volumes* has given the results of his investigations upon them. More recently two other naturalists, Professor E. D. Cope of

* "Extinct Mammalian Fauna of Dakota and Nebraska, with a Synopsis of the Mammalian Remains of North America," 'Journ. Acad. Nat. Science,' Philadelphia, 1869; and "Contributions to the Extinct Vertebrate Fauna of the Western Territories," 'Report of the U. S. Geological Survey of the Territories,' Washington, 1873.









W. West & Co. lith.

American extinct Mammals.

Philadelphia, and Professor O. C. Marsh of Yale College, have taken the subject in hand, both as explorers and describers.*

It must be premised that the material has come to hand so rapidly during the last three or four years that most of the information which has hitherto been given to the world, especially by the two last-named palæontologists, is in a very provisional and fragmentary state; and that until the flood of new discovery begins to ebb, and the few labourers in this plentiful harvest-field have leisure to prepare careful, elaborate, and, above all, well-illustrated descriptions of the specimens, we shall remain in much uncertainty about the real nature and relations of many of the animals of that strange old fauna, which at present are to us little more than names.

I must presume that readers are familiar with the main epochs of time into which geologists have divided the earth's history. For the present purpose we shall only have to refer to the latest of these, the Tertiary, representing how many millions of years we cannot say; and which, for convenience, is generally subdivided into four sub-epochs, the Eocene, the Miocene, the Pliocene, and the Pleistocene, the end of which brings us to the period in which we now dwell. Of course it is not implied by this division that there was any sudden break or interruption of the steady course of the world's progress between these periods. They are merely artificial and arbitrary, though convenient stages, and pass insensibly one into the other; but without the use of some such terms we could not fix the epoch of any particular event or set of events. In geology we know nothing of centuries. We have no kings' reigns, as in political history, to mark the course of time, so we speak of "Miocene" much in the same vague kind of sense in which we speak of the "Middle Ages" in our chronology of the historical events in Europe.

The first evidence of mammalian remains in strata of Miocene age in Western America was that made known in 1846 by Dr. Hiram A. Prout, of teeth then supposed to belong to a gigantic species of *Palæotherium*, and subsequently described by Leidy under the name of *Titanotherium*. This was the commencement of that interesting series of discoveries, which have now made the "Mauvaises Terres," or "Bad Lands," of the White River of Dacota, classical ground to the palæontologist. But it was not until 1869 that the older beds on the western side of the Rocky Mountains were explored, and the more ancient Eocene land fauna of North America brought to light. In that

* I am glad to take the opportunity of thanking Professors Hayden, Leidy, Marsh, and Cope, for their kindness in sending me copies of all their numerous memoirs bearing upon the subject of this article.

year commenced the explorations in the vicinity of Fort Bridger, a military post situated in the south-west corner of Wyoming Territory, which have yielded such an abundant harvest, and the locality of which is thus graphically described by Professor Leidy:—

"Fort Bridger occupies a situation in the midst of a wide plain, at the base of the Uintah Mountains, and at an altitude of nearly seven thousand feet above the ocean level. The neighbouring country, extending from the Uintah and Wahsatch Mountains on the south and west to the Wind River Range on the north-east, at the close of the Cretaceous epoch, appears to have been occupied by a vast fresh-water lake. Abundance of evidence is found to prove that the region was then inhabited by animals as numerous and varied as those of any other fauna, recent or extinct, in other parts of the world. Then, too, a rich tropical vegetation covered the country, in strange contrast to its present almost lifeless and desert condition.

"The country appears to have undergone slow and gradual elevation; and the great Uintah Lake, as we may designate it, was emptied, apparently in successive portions, and after long intervals, until finally it was drained to the bottom. The ancient lake-deposits now form the basis of the country, and appear as extensive plains, which have been subjected to a great amount of erosion, resulting in the production of deep valleys and wide basins, traversed by Green River and its tributaries, which have their sources in the mountain boundaries. From the valley of the Green River the flat-topped hills rise in succession, as a series of broad table-lands or terraces, extending to the flanks of the surrounding mountains.

"The fossils which form the subjects of our communication for the most part were derived from the more superficial deposits of the great Uintah basin, which Professor Hayden has distinguished as the Bridger group of beds. These compose the terraces or table-lands in the neighbourhood of Fort Bridger, and consist of nearly horizontal strata of variously-coloured indurated clays and sandstones. As the beds wear, through atmospheric agencies, on the naked declivities of the flat-topped hills, the fossils become exposed to view, and tumble down to the base of the hills among the crumbling *débris* of the beds."

The immense length of time that this ancient lake has existed may be inferred from the fact that the mud or sand deposited in it has accumulated to more than a mile of vertical thickness.

It is from this and from neighbouring localities systematically explored only during the last four or five years, both by the Government surveys and by expeditions organised for the purpose from Yale College, that most of the remarkable animals

attributed to the Eocene epoch have been obtained; although still more recently fossiliferous beds of the same age have been discovered both in Colorado and New Mexico, so rich as to give hopes that we are still only on the threshold of our knowledge of the wonderful fauna of the ancient American continent. Besides the extensive and older known Miocene and Pliocene beds between the Rocky Mountains and the Missouri, others of corresponding age have been discovered west of the Blue Mountains in Eastern Oregon.

I must now pass in successive review some of the principal groups into which animals have been divided by naturalists, and show what is known of their past history on the great North American continent. I am aware that the summary I am about to give will be exceedingly imperfect, partly on account of the limited time allowed in one discourse, and partly on account of the difficulty of extracting a connected account of these discoveries from the exceedingly numerous notices in which they are described—often fragmentary and disconnected, and even contradictory, and scattered through a variety of periodicals and reports. As most of these descriptions are put forth by their authors as "preliminary," to be superseded by more elaborate and detailed work hereafter, so must this notice of them be regarded. It will at least serve the purpose of calling attention to the importance and interest of this comparatively new field of research.

The first group to which I will direct attention, as it is that of the ancient history of which we have more complete knowledge than of any other, is the large order of *Ungulata*, or hoofed animals; and first among them I will consider those characterised, among many other distinctive peculiarities, by the uneven or *perissodactyle* structure of the foot, represented in the actual fauna of the world only by the three families of Horses, Tapirs, and Rhinoceroses—animals differing very considerably from each other in general outward appearance, and yet having many important common characteristics.

It is well known that in the Old World, species of this group, very intermediate in characters to those now existing, flourished in the Eocene age. Cuvier's grand researches in the Paris gypsum beds, which laid the foundation of the study of mammalian palæontology, reconstructed the form, now almost as well known as that of the existing tapir, of the *Palæotherium*; and numerous allied species have since been found, not only in France, Switzerland, and Germany, but in the corresponding beds in our own country. But in America, before 1869, not a single Eocene Perissodactyle had been discovered. In fact, as just mentioned, no Eocene beds containing the remains of terrestrial animals had been explored. Since that date, how-

ever, it has been ascertained that the region in which the stupendous mountain ranges of western North America have since been elevated were tenanted by animals of similar form and characters, and quite as varied in species and as numerous in individuals as those which at a corresponding period of time ranged through the marshes and forests of the Paris and London basins.

None of these appear to be identical specifically with the European forms; and even the generic indications, being often founded on very limited portions of the organisation only, as a few teeth, must be regarded as provisional. Many were undoubtedly quite distinct from any which we know from the Eastern world. It would be useless here to give a catalogue of the generic and specific names which have been given to the animals of this group already discovered. A brief mention of the most important and interesting will suffice. The two best known genera are those named by Leidy *Hyrachyus* and *Palæosyops*; the former is allied to the Lophiodons and Tapirs, the latter to the Palæotheriums. They both embrace animals in size varying from that of a small rhinoceros down to a peccary. The numerous modifications and combinations of characters found in forms apparently allied to them, which are little known to us at present except by the names given to them by their discoverer, will doubtless afford for a long time to come materials for the minutest scrutiny. Some appear to be allied to the European *Lophiodon* and *Hyracotherium*, one of which *Orohippus* (Marsh), seems to connect these forms through *Miohippus* and *Mesohippus* with the horse-like *Anchitherium*, and thus fill a link wanting in European formations in the pedigree of the Equine family. This animal, like so many other of the Eocene Perissodactyles, resembles the modern tapirs in retaining the fifth digit on the fore-foot, though, as in all known members of the group, the first was wanting, and both first and fifth were wanting to the hind-foot. Several species are described, but none larger than a common fox. One form only, *Diceratherium* (Marsh), is rhinocerotic. It is found in the uppermost Eocene strata of Utah, and gives the earliest indication of this group yet known. It seems, according to Marsh, to be connected with the lower Eocene *Hyrachyus* on the one hand, and the Miocene *Hyracodon* on the other.

In the Miocene period in North America the Perissodactyles attained a great development of form, variety, and size, the groups became more distinctly separated from each other, and some of them possessed remarkably specialised characters. True tapirs have not yet been met with in this period, which is rather remarkable, taken in conjunction with the present geographical distribution of that group. The Palæotheroid

and Lophiodont forms had nearly, if not quite, died out, but the more horse-like *Mesohippus*, *Miohippus*, and *Anchitherium* were abundant, and appear to continue the line from the Eocene *Orohippus* to the true horses of the Pliocene period.

Rhinocerotic forms now became ascendent, being represented by *Diceratherium* (Marsh), differing from all existing animals of the group, by having a pair of horns placed side by side on the nasal bones; and a very interesting genus, *Hyracodon* (Leidy), an animal with molar teeth and many other of the characters of rhinoceros, but having no nasal horn, and having a complete set of incisor and canine teeth, as in all the older Perissodactyles, which are lost in the more modern rhinoceros. It is therefore quite a connecting link between the Palæotheroid animals of the Eocene, and the true rhinoceros of the Pliocene, and occupies exactly the right geological horizon that such a form ought to do if the one has been genetically derived from the other.

Hyracodon, therefore, has a high place of interest among many of similar nature which have been revealed by our newly-acquired knowledge of the ancient American fauna. If, however, as is stated, the fifth digit of the fore-foot is only rudimentary, it could scarcely have been, as remarked by Marsh, on the direct line of descent from the four-toed Eocene to the equally four-toed Miocene rhinoceros, though certainly in such a case we know not what ought to be allowed for reversion.

The same period (generally speaking) also produced several species of a more perfect rhinoceros, still hornless, however, and resembling the contemporaneous European *Aceratherium*.

But the most remarkable of the Miocene Perissodactyles, and in some respects the most remarkable of all the animals which the recent explorations have brought to light, are a number of species of gigantic size, to the first known of which Leidy gave the name of *Titanotherium*, and of which other forms have been named by Marsh *Brontotherium*, and by Cope *Symborodon*.

They must, by their great size and strength, grotesque appearance, and general mode of life, have taken the place in the Miocene times of the then extinct *Uintatherium* of the Eocene, and were in their turn replaced by the Mastodons and Elephants of later ages. The rhinoceros of the present day will serve to give the best general idea of the appearance of these creatures, but some of them (for they seem to have been numerous both in species and individuals) approached nearer to the elephant in size and length of limb. The skull (Pl. CXXXVIII. figs. 1 and 2) in its general characters was quite rhinocerotic; but the nasal bones supported a pair of large, laterally divergent, rugged prominences, apparently for

the attachment of horns. The limbs were intermediate in proportions between those of the elephant and rhinoceros; but, as in the latter, the femur has a third trochanter, and a deep pit for the round ligament. The feet were short and stout, but in essential characters agree with the true Perissodactyles, and have four toes in front and three behind.

Numerous species have been described, both by Cope and Marsh, founded chiefly upon the form and direction of the horn cores on the nasal bones: they are all from the Miocene beds east of the Rocky Mountains, in Dakota, Nebraska, Wyoming, and Colorado; and there is no evidence of any of the *Titanotheridæ*, as the family should be called, after the first-characterised genus of the group, having survived to a later geological epoch.

FIG. 1.

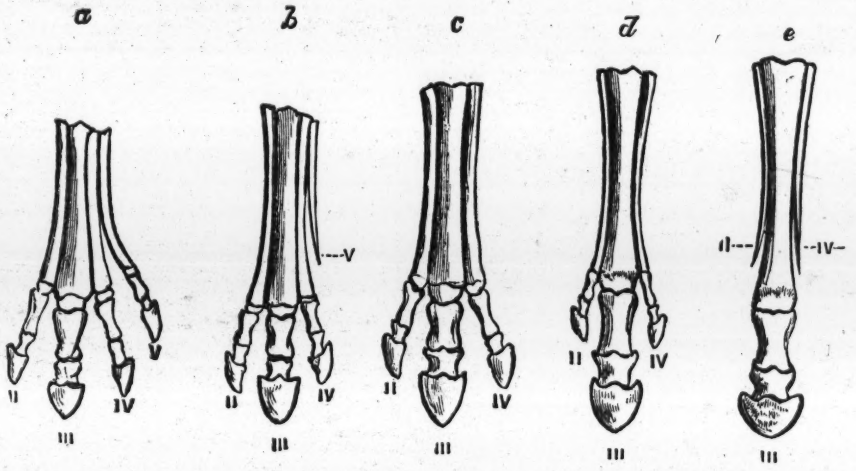


Diagram of several stages of modification of the feet of extinct forms of American horse-like animals (chiefly from Marsh), showing gradual reduction of the outer, and enlargement of the middle toe (III).

a, *Orohippus* (Eocene); *b*, *Mesohippus* (Miocene); *c*, *Miohippus* (Miocene); *d*, *Hipparion* or *Protohippus* (Pliocene); *e*, *Equus* (Pleistocene).

When we pass to the Pliocene and Pleistocene times, the Perissodactyles met with can all be referred to one or other of the three existing families; all the intermediate forms, and all those which have attained a different type of specialisation, as those last named, have completely disappeared.

Remains of several species of *Rhinocerotidæ* were very abundant during the Pliocene period in western North America; they all appear to belong to the hornless type, and from causes unknown became entirely extinct before the Pleistocene age. No rhinoceros exists now on the American continent, nor is there evidence that it ever supported animals belonging to the minor groups of the family to which the existing Indian, Sumatran, or African rhinoceros pertain.

During this period an immense development took place in the various forms of three-toed horses, *Anchippus*, *Protohippus*, *Parahippus*, *Hipparion*, &c., which replaced the *Anchitherium* of the Miocene. These in their turn, through many well-marked gradational forms (a full knowledge of which is among the many interesting results of these explorations), gave way to the true horses, of which remains of several species have been found in Pleistocene deposits, scattered throughout almost every region of the continent from Escholtz Bay in the north to Patagonia in the south. These also became entirely extinct before the discovery of America by the Spaniards—a most remarkable circumstance, considering the fitness of the country for their maintenance, as proved by the facility with which the descendants of horses introduced by European invaders have multiplied in a feral state.

On the other hand, of tapirs, fossil remains have been found most sparingly, though sufficient to show that they had a much wider geographical range northwards in the Pleistocene period than now, and yet several species of this genus still linger in the highlands of Central and South America, the sole direct representatives of the vast and varied Perissodactyle fauna of the continent in ages long gone by.

We may now pass to the remaining great group of hoofed animals, the even-toed or Artiodactyles, represented at present by the pigs, hippotami, camels, chevrotains, deer, antelopes, sheep, and oxen.

The remains of this group in the hitherto explored American Eocenes are very scanty and unsatisfactory as affording indications of its early history and development. Not a single specimen has yet been described which was found in a sufficiently perfect state of preservation to give a tolerably correct idea of its structure and affinities, and no forms corresponding to the well-established European *Anoplotherium*, *Dichodon*, *Xiphodon*, or *Cœnotherium* have been found. Towards the close of the period only (if the age of the Tertiary beds of Utah are rightly determined) do we find indications of well-defined crescentic-toothed or Selenodont species (*Agriochœrus*, Leidy), and also of tubercular-toothed or Bunodont forms (*Elotherium* and *Platygonus*). During the Miocene period, however, Artiodactyles of both these two main divisions abounded. It will be as well to take each group separately, and follow its history throughout, from the Miocene to the present day.

1. The Bunodonts, or those which inclined most to the pigs in dental structure. These were in North America, as in Europe, chiefly represented by animals of the genus *Elotherium*, huge swine-like creatures, some of whom approached the hippopotamus in size, and also by an allied four-toed form, *Pelonax*

(Cope), remarkable for its horn-like bony tubercles projecting out on each side from near the front end of the lower jaw. These became extinct, as in the Old World, before the close of the Miocene epoch.

Animals more like true pigs also existed, but all of the peccary type, the only one which now survives on the American continent. If the evidence of teeth alone can be trusted, this form, like the tapir (and the African *Hyomoschus*), is an unmodified remnant of the old Miocene fauna. But both at that period and in the Pleistocene, peccary-like animals existed in greater variety (as in the genus *Platygonus*), and in wider geographical distribution than at present. It is interesting to note that no remains of true *Sus* or any of its Old World modifications, as the wart hog (*Phacochœrus*), and babirussa, or of any species of hippopotamus, have hitherto been met with on the American continent. And thus the American Bunodont Artiodactyles, instead of undergoing great and diverse modifications, as did the corresponding animals of the Old World, have been gradually dwindling and contracting to the two closely-allied species of peccary (*Dicotyles tajacu* and *D. labiatus*), among the smallest and most insignificant of the whole group.

2. Of the Selenodont or crescentic-toothed Artiodactyles, the former existence in America of the long-extinct Old World genus *Hyopotamus* has been recognised by the discovery of a few teeth in the lowest Miocene of Dakota; and this is remarkable as the only recorded instance of an American form with three cusps on one of the lobes of the upper molars, a very common character among the European Miocene Artiodactyles.

Remains have also been found recently of various small ruminant-like animals, some not larger than a squirrel in size, to which the names *Leptomeryx*, *Hypisodus*, *Hypertragulus*, &c., have been applied. Whether these belonged to the family of Chevrotains or *Tragulidæ* (improperly called pigmy musk-deer), or whether, as appears more probable, they were not rather generalised or ancestral forms of the true Pecora or Ruminants, is difficult to determine from the present evidence.

Perhaps the most interesting of the American Miocene Artiodactyles, on account of their great abundance both in species and individuals, the full information which has been collected as to their structure, and their distinctness from any known forms from any other part of the world, is a family to which Professor Leidy applied the term *Oreodontidæ*. They played the part in the North American Miocene fauna which the deer do now in the same country, the antelopes in Africa, and the sheep in Central Asia. They were in nearly all points of structure intermediate between the ruminants and pigs, and

(with many other Old World forms, however) completely break down the line of demarcation which our knowledge, when limited only to the existing fauna of the world, caused zoologists to draw between those two groups.

They appear to have survived throughout the whole of the Miocene period, commencing in the genus called *Agriochœrus* in the uppermost Eocene, and ending in the *Merychyus* of the early Pliocene; and it is of great interest to know that a gradual modification can be traced in the characters of the animals of the group, corresponding with their chronological position, from the earlier more generalised to the latest comparatively specialised forms, thus affording one of the most complete pieces of evidence that is known in favour of a progressive alteration of form, not only specific, but even of generic importance, through advancing ages.

Another group of great interest made its appearance in the Miocene of North America, and which, if the evidence of fragments can be trusted, did not become extinct, like the last, but, continuing to exist through the Pliocene and Pleistocene ages, is still represented on two distant parts of the earth by the three or four species of llama of South America, and the two species of camel of the Old World. The discovery of the early Miocene *Pöebrotherium* and of the Pliocene *Procamelus* and *Pliauchenia*—remains of which, and of Pleistocene *Auchenicæ* of great size, though not generically distinguishable from the modern llamas, are abundantly distributed over the North American continent—seem to show that that country was the original home of the singular family of *Camelidæ*, which was probably introduced by emigration in its perfect condition into the Old World, where none of the transitional forms from the more generalised ruminants, like those above mentioned, have been met with.

On the other hand, of the gigantic four-horned *Sivatherium* of the Himalayas, the equally large but hornless *Helladotherium* of the Grecian Miocene, or of the giraffes, no representatives have hitherto been found in America. And very little light has been shed upon the origin and distribution of the true ruminants by these researches, except in a negative manner. No deer have been found in the Miocene (at which epoch they were abundant in Europe); in the Pliocene but a single and poorly developed species; while in the Pleistocene, with the exception of one large species, called *Cervus Americanus*, they scarcely differ from those of the actual fauna. Of the hollow-horned ruminants, several species of bison, of *Ovibos* or musk ox, and a single *Ovis*, have been described, all from the Pleistocene, but not a single species of antelope. From these facts it may safely be inferred that the few existing and Pleistocene

hollow-horned ruminants are immigrants of recent date from other lands; and it is probable that the deer have been similarly derived, though at a somewhat older period, which will account for their being more varied and wider spread in surface distribution, extending down almost to the southern extremity of the continent, while the hollow-horned ruminants are entirely confined to the north.

Scarcely any group to which the term "Order" is applied is so limited in the number of its existing species as that called, from one of the most striking external characteristics of the animals composing it, "*Proboscidea.*" The two species of elephant, that of Asia and Africa, the largest and in some respects the strangest of all land animals, are its sole representatives. Between these two animals and all others now existing there is a wide gap in numerous essential structural characters, so that really, in the world as we now see it, they have no near relatives.

But this was not always so. Leaving the existing condition of the earth's surface, and passing back to the last well-marked stage before our own, the Pleistocene period, we find abundant remains of elephants, imbedded in alluvial gravels, or secreted in the recesses of caves, into which they have been washed by streams or floods, or where, in many cases, they have been dragged in as food by hyænas or other predacious inhabitants of these subterranean dens.

We find these remains of elephantine animals extensively distributed over regions of the earth where no such creatures have existed within the memory of man. We find, moreover, that the elephants of the Pleistocene period, judging from their bones, and especially their teeth, do not in most cases exactly correspond in form or size to either of the existing kinds. We certainly find remains undistinguishable from those of the existing African elephant, in the north of Africa and southern parts of Europe; but the majority of these remains not only differ among themselves, but differ more or less from either the African or Indian species, and hence have had many different appellations bestowed upon them, as belonging to what are considered to be different species.

But not only in the Pleistocene period did elephants abound. Animals which must come within any definition which will include both *Elephas Indicus* and *Elephas Africanus* are also found in the European Pliocenes; and even earlier in Asia, the deposits of the Sivalik Hills, belonging to a transition between the Pliocene and Miocene age, are rich with the remains of elephants of varied form, in some cases presenting a considerable departure from our better-known types. Further back in time, however, we search in vain for true elephants. In the Miocene

period, it is true, many kinds of huge Proboscideans roamed over the surface of the earth; but these differ so much from what we now call "elephants," that it becomes necessary to distinguish them by another name; and that of *Mastodon*, first applied by Cuvier, is generally adopted.

Mastodons however were, after all, very like elephants, only being distinguished by some peculiarities of the teeth; and by means of intermediate species the two forms pass so gradually into one another, that it is difficult to say, in the case of some species, with which group they ought most properly to be classed. One other form of animal, which can be referred to the order *Proboscidea*, is known in the Old World—the *Dinotherium*, a huge beast, the nature of which for a long time was very doubtful, having been grouped by some naturalists with the Manatees, by others even with the Marsupials. Its remains have been found, though comparatively rarely, in Miocene deposits in Germany, France, Greece, Asia Minor, and India.

Here our knowledge of the history of the order *Proboscidea*, as derived from palæontological researches in the Old World, ends. The *Dinotherium*, being in its teeth and some other respects slightly less specialised than the other forms, constitutes some kind of an approximation to the Ungulate animals. especially the tapirs; but the gap to be bridged over is very wide; and no remains referable to animals of the order, or any intermediate forms between this and other orders, have been found in Old World Eocene deposits.

Let us now turn to America. Neither at the present time nor within the memory of man have any Proboscidean animals existed within the length and breadth of the whole continent. But at one time—and that, geologically speaking, a very recent one—both true elephants and true mastodons abounded in North America, and the last-mentioned genus extended far into the southern portion of the continent. The elephant, the remains of which are most abundant throughout what are now the United States, differed but very slightly, if at all, from that which at the same period ranged throughout the northern portion of the Old World from the British Isles to Alaska. The commonest species of mastodon (*M. Americanus*, or *Ohioticus*, or *giganteus*) seems to have survived to a much later period than any of its European congeners, and even to have been the last extinct of all the American Proboscideans. Remains of other elephants and mastodons, though not differing in any remarkable degree from well-known European forms, have been found in Pleistocene and (at all events with respect to the last-named genus) in Pliocene deposits; but, as far as the evidence is at present before us, nowhere earlier.

So far, then, we find that elephants and mastodons, of types

quite resembling those found in the Old World, but in less specific variety, appeared on the American continent at a later period than in the Old World (none having been found of undoubted Miocene age), and ultimately became completely extinct before the historic period. No animal corresponding to the *Dinotherium* has been found. We shall hardly, then, be prepared to look for primitive types of the race in earlier American formations.

Among the most remarkable discoveries of the Eocene formations of Wyoming, has been that of a group of animals of huge size, approaching, if not equalling, that of the largest existing elephants, and presenting a combination of characters quite unlike those known among either recent or extinct creatures, and of which there were evidently several species living contemporaneously. Bones of some of these animals were discovered by Professor Marsh and Lieutenant Wann, of the Yale College exploring party, near Sage Creek, Western Wyoming, in September 1870, and described by the former in the following year, though provisionally referred to the genus *Titanotherium*. Other remains were discovered and described by Leidy in 1872, under the generic name of *Uintatherium* (from the Uintah Mountains, near which they were found). Very shortly afterwards other portions of bones and teeth of either the same or closely allied forms were described by Marsh as *Dinoceras*, and by Cope as *Loxolophodon* and *Eobasileus*. Whether these names will ultimately be retained for separate generic modifications, or whether they will have to be merged into the first, it would be premature to attempt to decide upon the evidence before us. Until satisfactory grounds have been shown for considering them to be distinct, it will be best to speak of them all under the name which has the priority.

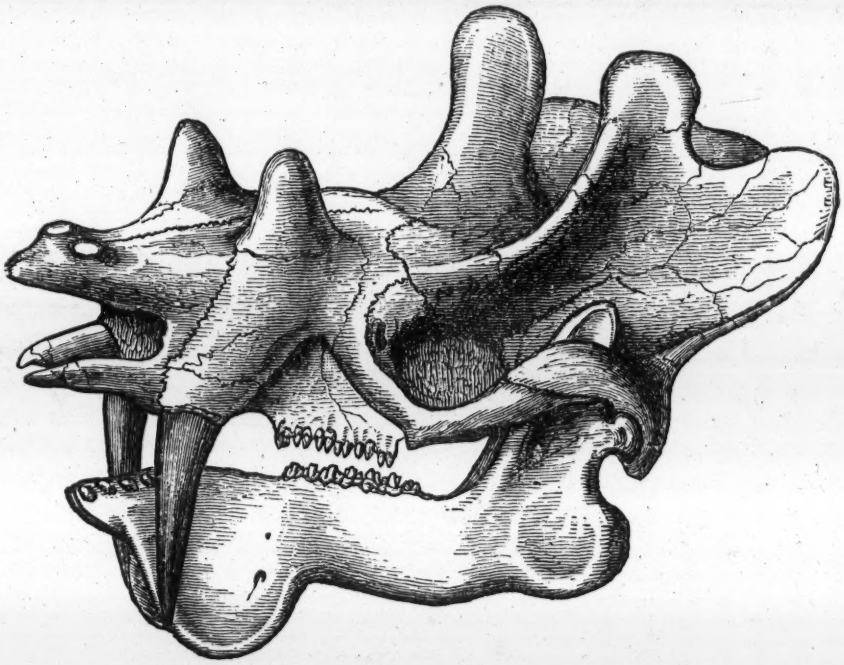
To form some idea of the general appearance of one of these animals, we must imagine a creature very elephant-like in its general proportions, elevated on massive pillar-like limbs, not quite so long, certainly, as those of elephants, but with the femur vertically placed, without third trochanter, and without pit for the round ligament as in those animals, the radius and ulna complete, and crossing, and the feet short, broad, massive, and with five toes on each. At first sight the skeletons of these feet (as figured by Marsh) show an extraordinary resemblance to those of the elephant, and to no other animal (see Pl. CXXXVIII. figs. 4 and 5), especially in the form of the astragalus; but on closer inspection it is seen that in the mode of articulation between the different bones of the carpus and tarsus they really come nearer to the rhinoceros and other Perissodactyles. For example, the upper end of the third metacarpal, instead of joining almost alone to the magnum, as in elephants, is united

by two nearly equal facets to the magnum and unciform, and the astragalus articulates largely with the cuboid, which it does not in the elephants. The presence, however, of five complete and distinct toes to the fore foot, and probably also to the hind foot, is a definite distinguishing character from any known Perissodactyle.

The vertebræ, in their main characters, resemble those of the Proboscideans; though the neck was somewhat longer in proportion. The tail was long and slender.

The head was long and narrow, and in its essential features more resembling that of the rhinoceros than the elephant. It

FIG. 2.



Restored skull of Uintatherium (*Dinoceras*, Marsh).

was elevated behind into a great occipital crest, as in the former, but, unlike that of any other unknown animal, it had developed from its upper surface three pairs of conspicuous laterally diverging protuberances, one pair (the largest) from the parietal region, one on the maxillaries in front of the orbit, and one much smaller than the others, near the fore part of the elongated nasal bones. Whether these were merely covered by bosses of callous skin, as the rounded form and ruggedness of their extremities would seem to indicate, or whether they formed the basis of attachment for horns of still greater extent, either like those of the rhinoceros or the buffalo, must still be a matter of conjecture. Whichever may have been the case, they would have given a very strange aspect to the creature

which possessed them, and have been formidable weapons in encounters either with animals of its own kind, or with the carnivorous beasts whose remains have been found associated with it.

The teeth were no less remarkable than the general formation of the skull. The dental formula was $i\ \frac{0}{3}, c\ \frac{1}{1}, p\ \frac{3}{3}, m\ \frac{3}{3} = 34$. The front teeth, or incisors, were, as in modern ruminants, absent above, and in the lower jaw rather small, directed forwards, and forming a continuous series with the still smaller canine. A large, trenchant, enamel-covered tusk, not unlike that of the musk-deer, or Chinese water-deer (*Hydopotes*), descended from each side of the upper jaw, and lay against a singular flattened expansion of the lower border of the ramus of the lower jaw, which has been conjectured to be for the purpose of protecting them from injury, though no such processes are found necessary in the animals above mentioned with similar tusks; and they recall a like conformation of the *Megatherium*, which can have no such function. They must have effectually prevented any stabbing or penetrating action of these weapons. There is some evidence that the tusks were smaller in the females. The molar teeth were six on each side, above and below, placed in continuous series, and separated from the canines by a considerable interval. They were small for the size of the animal, and of simple structure, each having two more or less transverse crests, though those of the upper jaw diverge externally, and meet at the inner border of the tooth in a V-shaped manner.

The brain (as indicated by the size and form of the cerebral cavity, of which a cast has been made and figured by Professor Marsh) was proportionately smaller than in any other known mammal, recent or fossil, and was almost reptilian in its character. (See Pl. CXXXVIII. fig. 3.) It was actually so diminutive (in Marsh's *Dinoceras mirabile*) that the entire brain could apparently have been drawn through the neural canal of all the presacral vertebræ, certainly through the cervicals and lumbars. It was therefore exceedingly unlike that of modern Proboscideans.

These animals, taking the totality of their organisation into consideration, appear to belong to the great Ungulated group, and to hold a position somewhat intermediate to the Perissodactyles and the Proboscidea, though nearer to the former than was at first supposed. This affinity is still further shown by the discovery of other forms, constituting the genera *Bathmodon* and *Metalophodon* of Cope, from an earlier geological horizon, which, with the general structure of the *Uintatheridæ*, retain, in an extremely interesting manner, many primitive

characters, common to all early Ungulates, especially the complete number of incisor and premolar teeth. These are forms for fuller information upon which we anxiously wait.*

It should be mentioned that Professor Marsh has made of *Uintatherium* and its immediate allies a peculiar order of mammals, to which he has given the name of *Dinocerata*, while Cope, who formerly included them in the Proboscidea, and placed *Bathmodon* with the Perissodactyla, has now ("Syst. Cat. of Vertebrata of the Eocene of New Mexico," 1875) formed an order called *Amblypoda*, of which the *Dinocerata*, containing the genera *Uintatherium* and *Loxolophodon*, is one sub-order, and the *Pantodonta*, containing *Bathmodon* and *Metalopholodon*, the other. Both, however, admit that they hold a position somewhat intermediate between the modern orders of Proboscidea and Perissodactyle Ungulates, and so stand out, as it were, as broken piers of the bridge by which the gulf which now so completely divides these orders might have been passed over.

The negative evidence (which of course must be received with the greatest caution in palæontology) of the absence of the remains of any of these animals in the Miocene or Pliocene deposits of North America, indicates that the race became extinct, at least in that land, though it possibly may have migrated elsewhere, and perhaps in Asia may have laid the foundation of that family, which first appears in the Old World under the more familiar form of the typical Proboscideans.

While, however, it would be the rashest possible assertion to say that these were derived directly from the Eocene Bathmodons and Uintatheriums, it is not too much to look upon the latter as affording us some indications of the steps by which the process might have taken place, and as such their discovery is one of the most interesting that has been revealed by modern palæontological research.

The history of the North American *Carnivora* may next engage our attention. In the actual condition of affairs, this order is tolerably well represented on that continent. The *Procyonidæ*, or raccoon-like animals, are almost peculiar to it; the bears, and their allies the otters, martens, and skunks are numerous. The dogs also are widely distributed and variously modified. The Felidæ, though tolerably abundant, do not attain the same size and strength as in the Old World, and the *Hyænidæ*, *Protelidæ*, *Cryptoproctidæ*, and the great family of *Viverridæ*, the civets and genettes, are entirely wanting.

As the modern tapirs and peccaries, which pursue their peace-

* It has been shown quite recently that *Bathmodon* is the same as *Coryphodon* (Owen) of the European Eocenes.

ful existence in the deep shades of the tropical American forests, frequently become the victims of the ferocious jaguars and pumas, which prowl in search of prey through the rank vegetation of the river banks, or lie in wait concealed amid the luxuriant foliage of the branches overhead, it is only natural to suppose that the countless herds of tapir and swine-like herbivorous animals which lived in a similar manner amid the ancient Eocene swamps and forests of Wyoming and Colorado, were also destined to furnish subsistence to a tribe of rapacious beasts of form and fashion long passed away. Palæontological research amply shows that this was the case. Side by side with the remains of *Hyrachyus*, *Palæosyops*, and the rest, are found bones and teeth of animals of various size and structure, but of undoubted carnivorous habits. Unfortunately at present most of these are known only by fragments, and not a few of the numerous genera recently described are founded on the evidence of a single tooth!

There are some, however, about which our knowledge has, within the last two or three years, been greatly extended, and which have proved to be of very special interest.

Among these are two genera, called by their describer, Professor Cope, *Synoplotherium* and *Mesonyx*, each represented by a single species, *S. lanius* and *M. obtusidens*; the latter the size of a large wolf, the former somewhat larger, both from the Eocene of Wyoming. These, like so many of the animals of the same period of the world's history, present such a combination of characters, that it is impossible to place them in either of the existing families of the order to which they belong, being in some respects bear-like, in others dog-like, and in some being more generalised than are any existing members of the order. For instance, their claws had not that narrow, compressed, curved, and sharp-pointed form seen more or less in all modern carnivores, and in the highest degree in the most typical or specialised members of the group, the cats; but they were nearly flat, straight, and blunt (from whence it has been conjectured that they were adapted for an aquatic life), and two bones of the carpus, the scaphoid and lunar, which in all existing carnivora (even including the seals) are united to form a single bone, were distinct from each other, as in the majority of mammalia. The lower canine teeth were placed very close to the fore part of the jaw, which appears to Professor Cope "a special modification for peculiar habits, which," he says, "I suspect to have been the devouring of the turtles, which so abounded on the land and in the waters of the same period. The slender symphysis could most readily be introduced into the shell, while the lateral pressure of the upper canines with the lower would be well adapted for breaking the bony covering of those reptiles."

In the character of the molar teeth, of which there were a considerable number resembling one another in form, these animals, and many others less perfectly known, resemble the well-known *Hyænodon* of Europe, a lost type of carnivorous animal first found in the Upper Eocenes of Europe, but abundant also in America at an apparently later age. The members of this group of carnivores are all characterised by long and somewhat slender jaws, containing a series of teeth one behind the other, each being in its form a repetition of the one before it, as in many of the existing predaceous marsupial animals. The greater differentiation of the characters of the teeth and the shortening of the jaws, with corresponding increase of the force with which they can be closed, seen in the highest forms of modern carnivores, is one among many examples of progressive adaptations conducing to more complete efficiency in performing the functions of life. These Eocene carnivores also (according to Cope) show a primitive character in the tibio-astragalar articulation, or "ankle-joint." "The astragalus is flat, and the applied surfaces are nearly a plane, and without the pulley-shaped character seen in existing carnivora, as dogs, cats, and, in a less degree, in the bears and in other mammalia with specialised extremities, as *Perissodactyla*, *Artiodactyla*, &c. The simplicity of structure resembles, on the other hand, that found in the opossum and various *Insectivora*, *Rodentia*, and *Quadrumana*, and in the *Proboscidia*, most of which have the generalized type of feet. The structure indicates that the carnivorous genera named were plantigrade—a conclusion which is in conformity with the belief already expressed, that the mammalia of the Eocene exhibit much less marked ordinal distinction than do those of the Miocene or the recent periods. It is, indeed, questionable whether some of the genera here included in the carnivora are not gigantic *Insectivora*, since the tibio-tarsal articulation in many, the separation of the scaphoid and lunar bones in *Synoplotherium*, the form of the molars, and the absence of incisor teeth in some, are all characteristic of the latter rather than the former order."

The Miocene carnivorous animals found associated with the herbivorous Oreodons of Dakota are more perfectly known, many of them having been well worked out and figured some years ago by Leidy. The most remarkable are several species of *Hyænodon*, a genus already mentioned as found in the Upper Eocenes and Lower Miocenes of France, and also of the south of England; but one of the American species (*H. horridus*, Leidy) is larger than any of its European congeners, its skull (which, as Leidy remarks, is not like that of any existing carnivores, but something intermediate between that of a wolf and an opossum) fully equalling that of the largest individual

of the black bear (*Ursus Americanus*); other species were not larger than a fox. These were the last survivors of a group notably different from any now existing.

The remaining American carnivores of the Miocene and more recent ages can be, as far as they are known, referred to one or other of the groups into which the order is now divided. The dog-like forms were abundant throughout the Miocene and Pliocene ages. But in the earliest period more generalised types were met with, assigned to the well-known European genus *Amphicyon*, which differs from the true dogs in the more tuberculated character of its molars, and the presence of the last upper tooth of this class, which is missing in the modern *Canidæ*, and also in the more bear-like structure of its limbs. Various modifications of *Felidæ* were also abundant, the most remarkable in the Miocene period belonging to that group (*Machœrodus* or *Depranodon*), with immensely developed sabre-like upper canine teeth, which flourished throughout such an extensive period of time and in so many parts of the world: in the sub-Himalayan region; in Miocene and Pliocene epochs in various parts of Europe, and almost down to recent times in England, as we know by the teeth found in Kent's Hole; in South America, where remains of its largest and most powerful form (*M. neogœus*) have been found in the caves of Brazil and in the alluvial plains of Buenos Ayres; and again in the Miocene of the North American territories. Why this form, so highly specialised for its mode of life, once apparently the dominating type of the whole order throughout the world, should have entirely disappeared, and given way to the more modestly armed modern tigers and leopards, is not very easy to explain.

From the time of the extinction of the sabre-toothed cats in North America, to the present period, other forms more like those now existing continue to prevail, none, however, equalling in size those of the Old World lion or tiger; but of the other families of the carnivora little has hitherto been found. *Ursidæ* and *Mustelidæ*, except in Pleistocene deposits, are very rare; and, what is more remarkable, remains that can with certainty be referred to the *Procyonidæ*, a group whose head-quarters are in America, have not been met with. The families which were previously mentioned as not now existent in that continent are equally unknown in its extinct fauna.

Perhaps the most conspicuous, both on account of their colossal size and their singular conformation and habits, of the animals inhabiting the American continent in the period immediately preceding the one in which we now live, were the great ground sloths, known to us familiarly by the names of *Megatherium*, *Mylodon*, *Megalonyx*, &c. As these animals are

peculiarly American, it might have been expected that when the earlier formations of the continent on which they flourished were explored, the remains of similar or at least allied forms would have been brought to light. But hitherto this has not been the case.

Two species of a genus (*Morotherium*, Marsh) allied to *Megalonyx* and *Mylodon*, from Pliocene strata in Central California and Idaho, have been described; but it is a most remarkable fact that not a fragment attributed with certainty to an Edentate animal has been found in any Miocene or Eocene deposit on the North American continent, and therefore (if this negative evidence can be trusted) we shall have to look elsewhere (probably to the Southern American continent) for the region which gave birth to these mighty creatures, and to look upon them as but temporary excursionists into the northern portion of the continent during the Pleistocene epoch.

On the other hand, numerous species of the orders *Rodentia*, *Insectivora*, and even *Chiroptera*, and some attributed to the *Marsupialia*, have been found in almost all the hitherto explored fossiliferous deposits down to the Eocenes. Of these time will not suffice to give an account, and this is less important as it is difficult to draw any general conclusions from the fragmentary descriptions of them which we possess at present. I must, however, not omit to call attention to two recently announced discoveries, which, when fully worked out, promise results of considerable interest.

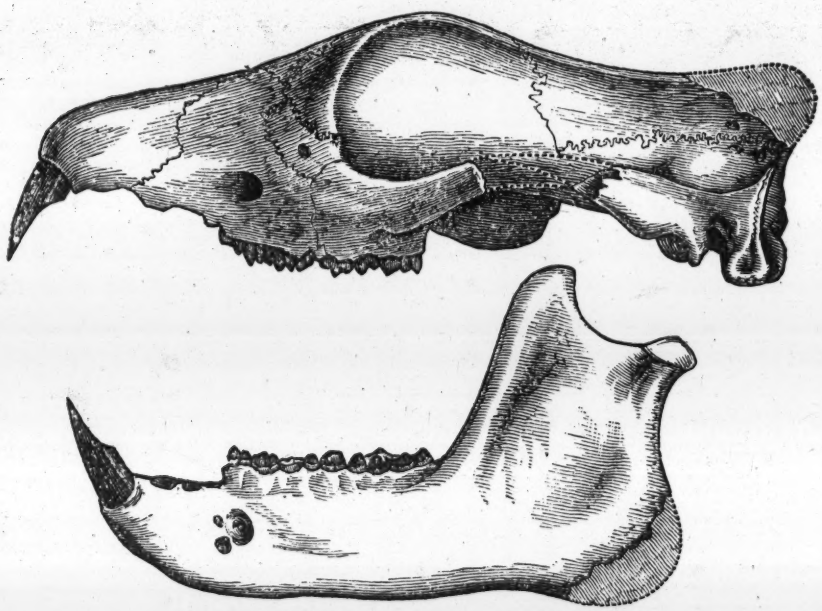
Professor Leidy, in 1868, described a single lower molar tooth from a Tertiary formation, supposed to be Miocene, of Shark River, Monmouth County, New Jersey, apparently of Ungulate affinities, and to which he gave the name of *Anchippodus riparius*. Subsequently a lower jaw of a very anomalous character, from the Bridger Eocene, with large rodent-like perpetually growing incisors, no canines, and bilobed molars, something like those of Palæotherium, was described by the same author under the name of *Trogosus castoridens*; but comparison with the single molar from New Jersey showed so close a resemblance, that the latter name was withdrawn, and both specimens referred to the first described, or *Anchippodus*.

Other similar forms found in a more perfect condition have been described by Professor Marsh, who at a meeting of the Connecticut Academy, Feb. 17, 1875, suggested that as they could be included in no known order of mammals, they should be placed in a new one, for which he proposed the name *Tillodontia*.

"These animals," Professor Marsh observes, "are among the most remarkable yet discovered in American strata, and seem to combine characters of several distinct groups, viz. Carnivores,

Ungulates, and Rodents. In *Tillotherium* (Marsh), the type of the order, the skull has the same general form as in the bears; but in its structure resembles that of the Ungulates. The molar teeth are of the Ungulate type, the canines are small, and in each jaw there is a pair of large scalpriform incisors faced with enamel, and growing from persistent pulps, as in the Rodents. The adult dentition is as follows: incisors, $\frac{2}{2}$; canines, $\frac{1}{1}$; premolars, $\frac{3}{2}$; molars, $\frac{3}{3}$. The articulation of the lower jaw with the skull corresponds to that in Ungulates. The posterior nares open behind the last upper molars. The brain was

Fig. 3.



Skull of Anchippodus (*Tillotherium fodiens*, Marsh), ¼, from Marsh, "Am. Journ. Sci. and Art," 1876, Plate VIII.

small, and somewhat convoluted. The skeleton most resembles that of carnivores, especially the *Ursidæ;* but the scaphoid and lunar bones are not united, and there is a third trochanter on the fermur. The radius and ulna, and the tibia and fibula, are distinct. The feet are plantigrade, and each had five digits, all terminated with long, compressed, and pointed ungual phalanges, somewhat similar to those of the bears. The other genera of this order are less known, but all apparently had the same general characters. There are two distinct families, *Tillotheridæ* (perhaps identical with *Anchippodentidæ*), in which the large incisors grow from persistent pulps, while the molars have roots; and the *Stylinodontidæ*, in which all the teeth are rootless. Some of the animals of this group were as large as a

tapir. With *Hyrax* or the *Toxodontia* they appear to have no near affinities."

The second recently announced discovery to which I alluded is, that a considerable number of fragments of teeth, jaws, and bones from the American Eocenes, the nature of which for some time was an exceedingly difficult problem, really belong to a low form of the great and important order *Primates*, an order embracing the lemurs, various species of monkeys, and culminating in man himself, and which hitherto has not been known with any certainty (except at least by some equally recent discoveries in France) to have existed in the Eocene period. The evidence, however, on which this announcement, made almost simultaneously by Professors Marsh and Cope, rests, is not very fully before the world. Already more than fifteen genera have been named and described, which are assigned to this group, and their characters are said to be those of a low or generalised form of lemur; while some are compared with the true monkeys. Far more rigid comparisons and carefully balanced deductions are required before we can assign their various species to their correct position, and appreciate their bearings upon the generic history of the Primates. In some of the descriptions at present before us lemur and monkey are used as convertible terms, and yet those who have studied these groups most closely are far from being able to pronounce upon the true relationship even of the existing species, and some even doubt whether they ought properly to be associated in the same order. But this is far too large a subject to discuss in all its bearings at the close of a discourse. I can only indicate it as one which may have much light thrown upon it by the researches of American palæontologists.

I can say nothing now of what is being done by the same persons, in the same regions of the world, with regard to other classes of animals than the one I have hitherto been speaking of. But the great and important discoveries of new forms and new links between old forms have not been confined to the mammalia alone. The knowledge of the past history of birds, reptiles, and of fishes, has likewise been greatly enlarged. The very remarkable discovery of Odontornithes, or birds with true teeth and other reptilian characters, has been made. Numbers of new invertebrates, and a whole world of new fossil plants, have been brought to light.

Apart from the special interest of the individual results, some few only of which I have been able to bring under notice on this occasion, the contemplation of what has been done in American palæontology in the last few years teaches us—First, that the living world around us at the present moment bears but an exceedingly small proportion to the whole series of

animal and vegetable forms which have existed in past ages. Secondly, that, notwithstanding all that has been said, and most justly said, of the necessary imperfection of the geological record, we may hope that there is still so much preserved that the study of the course of events which have led up to the present condition of life on the globe, may have a great future before it.—*A Lecture delivered before the Royal Institution, March* 10, 1876.

EXPLANATION OF PLATE CXXXVIII.

FIG. 1. Side view of the cranium of Titanotherium (*Brontotherium ingens*, Marsh).

FIG. 2. Upper view of the same, showing the size and form of the brain.

FIG. 3. Upper view of the cranium of Uintatherium (*Dinoceras*, Marsh), showing the size and form of the brain.

FIG. 4. Fore foot of Uintatherium (*Dinoceras*, Marsh).

FIG. 5. Hind foot of Uintatherium (*Dinoceras*, Marsh).

(All $\frac{1}{10}$ the size of nature. From Marsh's figures.)

REVIEWS.

DARWIN'S LATEST BOOK.*

THERE are not a few, even among Mr. Darwin's most enthusiastic admirers, who consider that the present work is the least attractive of the many volumes which the author of the "Origin of Species" has given to the public. And we agree with them to a certain extent, but only so far as the book possesses little to interest a general reader. Those who look on a vast piece of architectural workmanship, if they are of the general crowd, come away with but the vaguest idea of the building they have been looking at. What care they for the tremendous labour and the important skill which must have been displayed in the putting together of the various stones which make up its entirety. So likewise we fancy that of the many—and they are by no means exclusively men of science—who are lavish in their admiration of Mr. Darwin's writings, there are not a few who consider that this work on the domestication of animals and plants, while it may have cost a vast amount of time and labour in its execution, is nevertheless devoid of the interest belonging to other works by the same author. With the naturalist, however, the position is different. He can see at a glance how vast is the amount of evidence which the author has here collected in support of his doctrine of the evolution of races. The whole time of mankind on the earth is but a unit compared with the vastness of the period during which life has been upon the globe. Yet of the period of man alone, how far have we any evidence that is of value? Say about 3,000 years. That is to say, that we have personal observation—as in the records of ancient Egypt—which extends back about 3,000 years, and which shows us that certain animals—the dog, for example—had been bred as he is now. We must admit, then, how extremely difficult is the task of the natural historian who endeavours to find out within this period evidence which will be conclusive as to the tendency of animals and plants to vary, and by means of *natural selection* to have eventually certain species preserved as being the best adapted to the circumstances, while others as certainly "go to the wall" in the struggle for life, and are thus lost to posterity.

Still, small as the time relatively is, it is wonderful how much material Mr. Darwin has collected in these two volumes. Of course, having reviewed this

* "The Variation of Animals and Plants under Domestication." By Charles Darwin, M.A., F.R.S. Second Edition, 2 vols. London: John Murray.

work on its first appearance, we shall not do more than cursorily glance at the more important additions and alterations which the present edition contains; but we may express our wonder at the amount of matter which is collected on the subjects of the horse, ass, pig, cattle, dog, cat, rabbit, pigeons —especially pigeons—fowls, canaries, hive-bees, and silk-worms. And all this, which covers over 300 pages, and which is exclusively relative to animal life, is valuable original material, collected from various observations, beside those of the author, and dealing most minutely with the anatomical differences—in some instances most important—that are displayed by animals that have originally come from the same pair of ancestors. On the subject of plants Mr. Darwin's book is no less copiously instructive. And on such questions as inheritance, selection, variation, and pangenesis, which Mr. Sorby has recently supported,* and on which the author gives much additional argument to what appeared in the former edition of his work, the book is full as full can be. Perhaps one of the most interesting points in the present edition is the reference to Dr. Brown-Séquard's very remarkable results obtained from experiments on rabbits. These show us most conclusively—for the experiments have been tried on many thousands of specimens —that animals born of parents that have been rendered epileptic by section of the sciatic nerve, are themselves distinctly epileptic. And not only this; but that changes in the shape of the ear, ophthalmia, absence of toes, &c., occur in the descendants of animals in which these conditions have been the result of operation. Assuredly in such a fact as the absence of toes in the descendants of animals whose toes had been destroyed, we have—if the evidence is sufficiently powerful—an important argument in support of pangenesis.

We could quote more largely from the author's interesting researches, but we have done enough to show the great importance of his labours, and to prove the interesting character of the volumes under notice. In one or two instances in which Mr. Darwin has had to refer to papers in this journal, it is to be regretted that he omitted the word "Popular" from the title, as there may be some confusion as to the source referred to. It is to be observed, also, that the volumes are not so large in shape as the former ones; this has been effected by no change in the type, but by cutting down the pages a little. The result has been to make the work far more convenient for reading.

POPULAR CHEMISTRY. †

THERE is a considerable difficulty in reviewing such a book as that before us, from the circumstance that it is intended to play a double part. That is to say, that one is disposed to be neither severe nor unduly favourable in his notice of the work. But if one would honestly and bluntly express

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* In his address to the Royal Microscopical Society, published in the "Monthly Microscopical Journal," March 1876.

† "A Class-book of Chemistry on the Basis of the New System." By Edward L. Youmans, M.D. London: Henry S. King & Co. 1876.

his opinion, it must be at once said that, somehow or other, the result of reading it is unsatisfactory. If truth must be told, the volume is one which neither possesses the information that is required by the earnest student, nor places the facts of the science in so popular a position that the unlearned in chemistry may read it with profit. We might take several examples of this tendency of the book, but one or two will suffice. We turned in the first instance to the chapter on Polarisation, as in that we were sure to find the author's popular mode of teaching put to a severe test. But what did we find? Why, that he has just given the usual explanation, and has not attempted anything in the way of genuine popularisation. We confess that if we were unacquainted with physics, and turned to Dr. Youmans' work for an explanation of this complex phenomenon, we should be no wiser after reading his account than we were before. But we will take another example in order to show our readers that we are entirely unprejudiced in the matter, and that Dr. Youmans is absolutely incapable of really popularising a difficult subject. The quotation we will make refers to the theory of *Atomicity* and *Quantivalence*; and Dr. Youmans' remarks on the subject of "variable combining capacity" are as follows:—"The general theory of chemistry now adopted is the outgrowth of preceding theories, and embodies the truths they have severally attained. But it adds an important principle which throws further light upon chemical operations, and serves to organise into a better system the later facts and ideas of the science. The notion of equality between combining elements and of equivalence among their atoms has long been fundamental in chemistry. When the substitution theory arose," &c., &c.

We think we have given enough to create dismay in the minds of all lovers of genuine popular science. However, there is something to be said in the author's favour. He has popularised many important points with considerable success, and he has supplied diagrams and drawings very freely, while withal he has furnished a series of questions at the termination of the book which will, we doubt not, be found extremely useful by the young student.

ANIMAL MORPHOLOGY. *

THE Professor of Zoology in the University of Dublin has long been known as a comparative anatomist of no mean ability, more especially in regard to those classes of the animal kingdom which come beneath the division Vertebrata. But we have not heard of him as one who was specially devoted to the various Invertebrate groups of animals. Yet it is especially on the classes that are included in the Protozoa, Cœlenterata, Mollusca, Annulosa, &c., that we find him writing in the present volume. We note, moreover, that he is modest enough in his preface, for he assumes that his book will form, as it were, a sort of introduction to the works of Rolleston, Huxley, and Flower. However, we fancy that most students will find that

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* "An Introduction to Animal Morphology and Systematic Zoology." By A. Macalister, M.B., Professor of Comparative Anatomy in the University of Dublin. Part I. Invertebrata. London: Longmans. 1876.

the present work will prove for all purposes of examination sufficiently modern and adequately advanced. At least we think so ourselves. The author commences by a series of remarks on protoplasm, general morphology, histology—of the muscular, nervous, and connective tissues—tectology, reproduction and distribution which is given both as to space and time. Of these several chapters we have not much to say. They appear generally good, but the remarks are excessively brief, and in one or two cases are by no means what we should have anticipated. This may be said especially of the author's observations on the subject of muscular tissue. We observe, too, with some pain, that the author does not seem to have accurately understood Mr. Darwin's remarks on the subject of natural selection. At least it seems so to us. For example, Dr. Macalister says: "But while explaining the method, natural selection does not explain the cause. In artificial selection the cause is the presidence and direction of human intellect. In natural selection there is a necessity for predicating the existence of a presidence similar in kind, but grander in degree, as the changes effected by it are greater than those that artificial selection can accomplish." We certainly fail to see the reason alleged, and we should much like to hear the author's opinion more fully on this point.

In regard to those portions of the work which deal with the purely zoological parts of the subject we have only praise to offer. We think the author has endeavoured to state points that will be useful to the reader, to the exclusion of new matter which refers to but single points, and which has not yet been clearly established. We note, too, that in almost every instance where a new fact is stated, the author's name which is most directly associated with it is given in parentheses.

It may be stated, as points objectionable in the work, firstly, that the author is accustomed to giving a great series of new words which *he* thinks—but we do not—serviceable from being an abbreviated mode of obtaining information; secondly, that the work is lamentably badly illustrated, the total number of woodcuts being about forty in number.

COLLECTING NATURAL HISTORY OBJECTS.*

A VERY valuable series of papers, which originally appeared in "Science Gossip," is here reprinted with their authors' names attached, and the whole has been issued under the editorship of Mr. J. E. Taylor, who contributes the first chapter on the subject of Geological Specimens. We may say at the outset that the work is eminently a practical one, and we doubt not will have a very large sale among all dilettanti naturalists. It is generally clear and to the point, while wherever illustration is required it is given. It is remarkable, too, that in a book which is written by a great number of naturalists, the general plan has been followed by all; and this

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* "Notes on Collecting and Preserving Natural History Objects." Edited by J. E. Taylor, Ph.D., F.L.S., F.G.S. London: Hardwicke & Bogue, 192, Piccadilly. 1876.

is a circumstance for which we must thank the editor in no small degree. Besides the Geological chapter to which we referred above, and which is written in an admirably popular and withal accurate style, the following sections make up the volume:—"Bones," by E. Elwin; "Birds'-eggs," by T. Southwell, F.L.S.; "Butterflies and Moths," by Dr. Knaggs; "Beetles," by E. C. Rye, F.L.S.; "Hymenoptera," by J. Bridgman; "Land and Freshwater Shells," by Ralph Tate, F.G.S.; "Flowering Plants and Ferns," two chapters, by J. Britten, F.L.S.; "Grasses," by Professor Buckman, F.G.S.; "Mosses," by Dr. Braithwaite, F.L.S.; "Fungi," by Worthington Smith, F.L.S.; "Lichens," by the Rev. James Crombie, F.L.S.; and "Seaweeds," by W. H. Grattan. Anyone who is at all familiar with natural history-workers will see at a glance that in most instances—as, for example, in those of "Fungi," "Lichens," "Mosses," &c.—the names of the authors selected are those of the very highest living authorities in their several departments. In each chapter we find ample instructions as to the implements to be employed, and the mode of using them in the capture of the several forms. But we are also informed as to the time and place in which the particular "quarry" is to be best taken; and, further, there is ample information supplied as to the best and most charitable mode of killing live animals, and as to the manner in which they shall be mounted after death. And now—having said so much in praise of this little book—must come a word or two in disparagement. It is to the technicalities which the authors employ that we object. Of course in some instances it is impossible to substitute common names, but in many cases the substitution is perfectly practicable and ought to have been adopted, and we trust will be followed in the next edition. The only chapter with which we can find no manner of fault in this respect is that which opens the work, and is by the editor. But certain others—we shall not name them—are as full of technicalities as it is well possible to be. Still the work is the only one of the kind, and it is *tout ensemble* an excellent one.

FERMENTATION.*

THIS book will, we doubt not, prove of interest to chemists; but we fear that the practical element is wanting which would have recommended it to a large number of readers who are engaged in our large breweries. Indeed, we think that the author has been forced to spin out his matter, so to speak, in order to make a book upon the subject. We note, too, that he is clearly ignorant of the lives of the lower groups of fungi, and we think that for this he is to blame; for assuredly, even though he may have been ignorant of the development of common *Mucor* at the period when he began his work, the study of the subject in any treatise on fungology need not have taken up very much of his time. It is also to be observed that his figures are insufficient, and the microscopic observations are taken altogether

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* "On Fermentation." By P. Schützenberger, Director at the Chemical Laboratory of the Sorbonne. London: Henry S. King & Co. 1876.

second-hand from other artists. But when we have said this we have expressed ourselves to the fullest extent that adverse criticism can urge us. There is a good deal that is most interesting in the book; and although, of course, it does not clearly define many of the points, it is needless to observe that this results from the fact that few of the great questions—those which have formed the discussions that took place some years ago between Baron Liebig and M. Pasteur—are even at the present moment in anything like a settled condition. M. Schützenberger, who is evidently of German origin, though attached to the laboratories of the Sorbonne, begins of course with the history of the subject, and treats us to several pages on this matter. And here we might observe that dealing with questions like the present one is utterly impossible in anything like the space at the writer's command. So this chapter might well have been omitted. The following are the headings of the several subsequent sections:—Alcoholic Fermentation; Alcoholic Ferments; Composition of Ferments; Function of Yeast; Action of various Agents on Alcoholic Fermentation; Can nothing but Alcoholic Yeast excite Alcoholic Fermentation? Mannitic Fermentation of Sugar; Lactic Fermentation; Ammoniacal Fermentation: Butyric Fermentation and Putrefaction; Fermentation by Oxidation; Application of the Researches of M. Pasteur; Albumenoid Substances; Origin of Ferments; Proteids; Soluble Ferments; and last, but not least, On the Origin of Ferments. There is nothing new in this book to those who have regularly read the "Comptes rendus" for the past twelve years. But for English readers alone there will be found an immense mine of valuable information, with reference more especially to the ideas of M. Pasteur. It is singular, however, that much as is the knowledge that has been obtained on the subject of fermentation generally, so little should have been done in the investigation of those diseases which are known to have their origin in the presence of certain fermenting materials within the body of the animal affected. On this point the author says—referring to a page which he has been quoting from a former work on M. Davaine's inquiries—that "during the ten years that have elapsed since this was written, skilful experimentalists, guided by the same ideas, among whom I may mention Pasteur himself [researches during the cholera epidemic], have studied this subject with great care; and yet I must admit that there has been no result from these inquiries; the question of the etiology of infectious diseases has made no important advance; the observation made by M. Davaine remains without any additional support." Those who remember the nature of Davaine's inquiries are aware that they were made upon animals infected with malignant boils.

On the subject of the French work that has been done on the question of fermentation, the reader will find ample details given, while the style is generally a most pleasant one; and though the book is deficient in its practical details, nevertheless it is an important, and therefore a welcome, addition to our literature.

AMERICAN SURVEYS.*

THE report of Captain Jones contains an account of a reconnaissance made in 1873, in North-Western Wyoming, with a view of finding a good and shorter route from the South, by the Wind River Valley and Upper Yellowstone to Montana; and from which it appears a district of considerable economical importance would be opened out, both as regards the agriculture and the mineral resources of the districts, especially of Montana, which is considered to be one of the most productive mining regions of the West. It is accompanied by a general map and forty-nine trail-maps, showing the physical features of the country passed over, of which an account is given in the text. The volume also includes reports on the Botany, Entomology, and Geology of the district explored. The latter, by Professor Comstock, gives a general review of the various formations observed, and the results of the dynamical forces which have operated, as well as an elaborate and interesting account of the Hot Springs and Geysers which form so remarkable a feature in the Yellowstone district. These phenomena of post-volcanic activity must have been very extensive and of long duration, for there is evidence of the existence of large tracts of ancient hot-spring deposits in many places where there are no signs of present or very recent activity, showing the amount of vigour that has been displayed at a remote period, though geologically recent, and the persistency of the heat to the present epoch. The first number of the Bulletin is mainly occupied with a series of interesting accounts of the ancient remains, ruins, and works of art found during the progress of Geological Survey of the Territories, which are fully illustrated by maps, plans, and numerous plates of the different points explored. The bead ornaments used by the prehistoric people of Utah and Arizona for personal decoration appear to have been of four kinds—shells, chiefly the genus Oliva; earthenware beads, turquoise very rare, and pendants made usually of stone or silicified wood, but occasionally of pieces of pottery. Some such ornaments as these are still worn among the Mojaves, Moquis, Pueblos, and Zuñians of Arizona and New Mexico. The second part is entirely ornithological, and contains studies of the American Falconidæ and the Ornithology of Gaudeloupe Island, by R. Ridgway.

A volume of 500 pages† records the progress of the operations of the geological survey in the more rugged mountain portions of Colorado during the season of 1874, and shows the continued activity of Dr. Hayden, the members of his staff, and the other collaborators who have contributed to its pages. Dr. Hayden gives a résumé of the geology of the eastern base of

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* "Report upon the Reconnaissance of North-Western Wyoming, including Yellowstone National Park." By Captain W. A. Jones. With Appendix. Washington, 1875. "Bulletin of the United States Geological and Geographical Survey of the Territories." Vol. ii. parts 1 and 2. Washington, 1876.

† "The United States Geological and Geographical Survey of the Territories, being the Report of Progress for the year 1876." By Dr. F. V. Hayden. Washington. 1876.

the Colorado range, and of the Elk Mountains, as well as an account of the characters, extent, and probable age of the lignitic group, and also an interesting chapter on glacial lakes and lake-basins, in which is shown the effects of glacial action and other denuding agencies of erosion in giving form to the rocky ranges of the West, where in some cases more than 10,000 feet of sedimentary strata have been swept away at a comparatively modern period. Professor Lesquereux contributes an important paper on the cretaceous and lignitic floras of North America, with descriptions of some new species. There are also reports on the geology of the Elk range, Middle Division, San Juan district, and Nebraska, by Messrs. Holmes, Peale, Endlich, and Aughey, besides reports on zoology, archæology, and topography. These reports are accompanied by nearly ninety maps, plans, sections, and plates, illustrative of the various subjects treated of in this volume.

GEOLOGICAL MANUALS.*

THE issue of a second edition of the useful "Guide to the Geology of London and the Neighbourhood," by Mr. Whitaker, in so short a period after the publication of the first, proves that it has been very acceptable to a large number of persons who are interested in and anxious to acquire a general knowledge of the character and arrangement of the various formations which occur in and near the metropolitan area. This new edition contains references to the memoirs of geological survey, where details of the sections noted may be found.

The second edition of the "Rudiments of Geology," by Mr. Sharp, has been thoroughly revised, and several important additions have been made throughout. The subject-matter is generally clearly and concisely treated, and so arranged, together with some tables and woodcuts, as to render it a more useful hand-book for the student of the science.

The little work by Mr. Mello is intended to give a general sketch of the geology of Derbyshire. With the exception of some mammalian gravels and bone-caves of Pleistocene age, the geology of the county is comparatively simple, consisting of the Trias, Permian, and Carboniferous formations; the latter occupy about two-thirds of the whole area. With the exception of a small inlying portion of the Leicestershire coal-field in the extreme south of the county, the coal measures of Derbyshire, with an area of about 230 square miles, are a continuation of the great Yorkshire coal-field. It is partly to the underlying millstone grit and mountain limestone, aided by denudation, that Derbyshire owes the wild and picturesque features of its dales and the long stretches of moorland, while the wooded and more cultivated southern portion occurs upon the softer Triassic strata.

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* "Guide to the Geology of London and the Neighbourhood." Second edition. By W. Whitaker, B.A., F.G.S. London: E. Stanford, 1875. "Rudiments of Geology." By S. Sharp, F.S.A., F.G.S. London: E. Stanford, 1876. "Hand-Book to the Geology of Derbyshire." By the Rev. J. M. Mello, M.A., F.G.S. London: Bemrose & Sons.

The work by Professor Green * must be classed among the advanced manuals for the teaching of geological science, and is not only intended to serve those students who desire to know as much of the science as any man of culture may be reasonably expected to possess, but also to form a text-book for the school and lecture-room, the author feeling that any work on natural science which is intended for educational use, and to assist the mind to reflect and reason, must not only state clearly the results arrived at, but must also put forth the methods by which they have been obtained. This idea seems generally to pervade the work. In this volume the facts bearing on the fundamental groundwork of the science are only attempted, and include the principal points of lithological and dynamical geology. A short chapter on the aim and scope of geology, with a sketch of its rise and progress, is followed by a description of the chief rock-forming minerals and a classification of rocks according to their two chief modes of origin, and their petrological characters; the volcanic, metamorphic, and granitic rocks being separately described. Denudation and its results, both as forming new deposits, and its effects in the shaping of the surface, are fully treated, as also are the various changes in position which rocks have undergone since they were originally deposited. The last two chapters are devoted to the original fluidity and present condition of the interior of the earth, with some remarks on speculative geology, and how the various changes of climate inferred by the geologist have been brought about. The clear and philosophic manner in which the various subjects are generally treated, and the numerous original and well-selected illustrations, as also the many notes and references to other works where more detailed information can be found, will render this book a valuable addition to the other treatises on the science.

BOTANICAL NAMES.†

FOR the general reader this book will not have special interest, but for the botanist it possesses many charms. It is an account of how botany first came to be studied, even before the Christian era, and during the last eighteen centuries; and added to this is a short description, in alphabetical order, of the origin of the several terms that have formed generic titles. The first part of the book is the most interesting, as it is also the best done. The second part is the more imperfect, but its importance cannot be overrated. We have seen nothing in the shape of a popular account of the meaning of botanical expressions but that of Mrs. Lankester, who, it will be remembered, was the joint editor of the last edition of Sowerby's botany. The account she has given, too, has to do with the significance rather of the popular names than the more specially scientific ones. Still it was unquestionably a very excellent addition to Dr. Syme's labours. Mr. Alcock has endeavoured to give the exact meaning which

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* "Geology." By Professor A. H. Green, M.A., F.G.S. London: 1876.

† "Botanical Names for English Readers." By R. H. Alcock. London: L. Reeves & Co. 1876.

each scientific name had at the time when it was first applied; and as it is his first attempt, of course every allowance must be made. At the same time, we think that many of his explanations are very far-fetched. Let us take, for example, *Bartsia odontites*; in this case he says that Pliny asserts that a portion of the stem was used for curing tooth-ache, hence the specific title. Again, *Borago* he attributes to the words *Cor* and *ago*: also *Camelina*, which he derives from *chamai*, the ground, and *linon* flax, which we think few who know the plant will agree to. Finally, the word *Euphorbia*, the derivation of which is attributed to Euphorbus, a physician to the King of Mauritania; and why, save for the resemblance of the names, remains a perfect mystery.

We have chosen these few examples, but we might have added very largely to the list had we chosen to do so. It seems to us that the author has not been very learned on the subject, and that he has overlooked many valuable sources of information in the botanical writings of the past couple of centuries. Still we must own that he has done a good work which we wish every success to, and we trust that when it comes to a new edition the author will enlarge and otherwise improve it. The history of botany, which precedes the dictionary, is most excellently given.

ANTI-DARWINISM*.

WE are somewhat amused, but not at all surprised, at a lawyer's coming forward in the ranks of Mr. Darwin's assailants. And, what we might have very naturally anticipated, viz. that the effort would be of a kind to resemble the mode of argument that is termed "special pleading," is clearly the sort of thing which we have to deal with. The arguments in the book before us are those which we have often heard urged against Mr. Darwin, which are almost universally of one class. We use the word "almost" because we wish to exclude one work, which is certainly a clever one, but which is opposed to the Darwinian theory. It might be fairly asked, how could a gentleman whose legal practice admits of his writing a book on the "History of the Currency" have had the opportunity of fairly considering the arguments in favour of Mr. Darwin's doctrines? He might, to be sure, have taken some half-dozen works, and skimmed them through in his chambers. But what a preparation would this be for the consideration of the grandest problem that has ever presented itself to the mind of man! Mr. James Maclaren presumes, we suppose, that Mr. Mivart has not made the most formidable onslaught on the Darwinian theory, and he therefore merely uses a few of his arguments. But indeed it is not worth while treating at length of this book, which, however fairly it may pretend to have been written, is the weakest and most one-sided argument in existence. Let us take one example of the author's powerful mode of argument as to the ape-origin of man:—

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* "A Critical Examination of some of the principal Arguments for and against Darwinism." By James Maclaren, M.A., Barrister-at-law. London: E. Bumpus. 1876.

"There is nothing, however, in this view of the progress of man which shows that he has descended from an ape-like ancestor; in fact, the general diffusion of man over the earth (and many evolutionists suppose that this diffusion took place before man had acquired language) is quite inconsistent with a development from an ape-like creature, as all existing man-like apes are, as we have seen, extremely local, capable of existing in a few spots only."

The other arguments are like the above, and may be left to the reader's judgment for their annihilation. But we would ask the author one question on the subject he has written on. Suppose a man, with no particular religious belief, who admits the possibility of there being a Creator, were to ask, "How has man come on the globe? There is much evidence of his kinship with the lower animals; whence, then, comes he?" What would be his reply? We suppose we shall have to wait his next volume for an answer.

OUR FIVE SENSES.*

WE think that Herr Julius Bernstein is to be congratulated upon the style of this book. We are much pleased with the manner in which he introduces us to the various subjects he has undertaken to describe, and indeed altogether his language is clear and to the point. He has taken the five senses, *i.e.* sight, hearing, touch, taste, and smell, to describe, and with each of them he has dealt fairly—more especially with the senses of sight and hearing. Of course it must not be imagined that he has told us anything new; that would be a great mistake. On the contrary, there are many points unnoticed in this book which Dr. Tyndall has expatiated at length upon in his various writings. Still he has stated the main points in an admirably lucid style. He gives more than 100 pages to the sense of sight alone, and he supplies numerous illustrations—some of them too familiar, perhaps—of the different experiments that are to be made on the subject of vision. In one of these, however, we note that a series of figures which are intended to look of different sizes though actually of the same size, are slightly misplaced, so that people view them at considerable disadvantage. There is absolutely nothing new in the entire volume, but still it will prove, we do not doubt, a very useful addition to our popular natural philosophy libraries.

SHORT NOTICES.

Bulletin of the United States National Museum. Washington: 1875.—In this number Professor E. Cope has published a check-list of North American Batrachia and Reptilia, with a systematic list of the higher groups, and an essay on their geographical distribution.

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* "The Five Senses of Man." By Julius Bernstein, Professor of Physiology at the University of Halle. London: Henry S. King & Co. 1876.

Mr. Brough Smyth, Secretary for Mines for Victoria, has prepared a detailed descriptive catalogue of rocks, minerals, and fossils illustrative of the geology, mineralogy, and mining resources of the colony, exhibited on behalf of the Government, at the Philadelphia International Exhibition, 1876.

Telegraphy. By W. H. Preece, C.E., and J. Sivewright, M.A. London: Longmans, 1876.—This is one of Messrs. Longmans' excellent manuals. It is essentially a practical work, intended as an introduction to Culley's famous treatise, which was noticed in these pages a few years ago. The authors explain that the work is intended alone for those who have been engaged in practical telegraphy. To such we recommend the volume. Its cuts are excellent.

Exercises in Electrical and Magnetic Measurement, with Answers. By R.E. Day, M.A. London: Longmans, 1876.—These are carefully prepared, and they will be found useful by all who are engaged in the practical study of electrical and magnetic apparatus.

Evolution of the Human Race from Apes &c., &c., unsanctioned by Science. By T. W. Jones, F.R.S., F.R.C.S., Professor of Ophthalmic Medicine and Surgery in University College, London. London: Smith & Elder, 1876.—Here is an admirably written and spirited essay against Darwinism. We recommend it to our readers' consideration because we are sure that they will peruse it with pleasure, and will put it down more convinced of the truth of Darwinism than they were before.

The Moon and the Earth. By T. M. Reade, C.E., F.G.S., President of the Liverpool Geological Society. London: Hardwicke & Bogue, 1876.—Those of our readers who have looked at the admirable series of representations in Messrs. Nasmyth & Carpenter's fine treatise on the Moon will not agree with Mr. Reade's conclusions. Still there is a good deal to be said for his ideas as to the comparison between the earth's and moon's appearances. It certainly does appear as if there were no disturbing influence in the case of the moon as there is in the earth's atmosphere. At the same time one is bound to ask how so much volcanic agency as once existed at the moon's surface could have operated without the presence of oxygen? In any case Mr. Reade's little pamphlet is a most interesting one.

We have received:—"Gumpel's Patent Rudder" (London: J. Pettitt, 1876); "Vis Inertia at the Post Office" (fourth edition, Longmans, 1876); "Why do we Breathe?" by P. Black, M.D.; "Annual Report of the Marine-Hospital Service of the United States, 1873;" "Annual Report of the Supervising Surgeon of the Marine-Hospital Service of the United States, for 1874;" "Science made Easy;" a series of Familiar Lectures," &c., by T. Twining. Parts I., II., III., and IV. (London: Chapman & Hall.)

THE LOAN COLLECTION OF SCIENTIFIC APPARATUS AT SOUTH KENSINGTON.

THOSE who have not yet visited the collection of apparatus at South Kensington can have little or no idea how vast and important it is. Those who have, however, will readily pardon us for not doing more for our readers than giving a general sketch of the exhibition, which is on the whole the finest that has ever been made, or in all probability ever will be made within our ken. At the same time we think that those who have superintended the work of exhibiting the various apparatus have been to blame in two distinct ways: 1st, in exhibiting many instruments that have not the slightest claim to novelty, but are merely exhibited because the particular makers had influence over those who had to do with the matter. 2nd, for the abominable manner in which some of the apparatus is exhibited, being in fact of no use whatever to students who desire its close examination. There is also a deficiency of labels explanatory of the objects. It is all very well to urge upon the spectator that he can readily obtain a catalogue, though unfortunately such cannot be had; but an exhibition which is got up by Government should not have been wanting—as this one is sadly—in explanatory labels. Those who had the management in their hands should have taken a lesson from the highly satisfactory arrangement that is invariably pursued in the South Kensington collection. The following notes are taken from a series of valuable articles which appeared in the "Academy" (May 20, and subsequent numbers):—Following the order of arrangement in the building, the first Section is that under which "Educational Appliances" are classed; and here the most striking feature is the collection forwarded from Russia by the Committee of the Pedagogical Museum; the models by Strembitsky, which belong to this series, are extremely good and very instructive. Germany has contributed largely to this section, and several private firms have sent well-filled cases of apparatus for teaching physical science. England is fairly represented, but from France there is nothing, and from Austria, Italy, Holland, and Belgium a few objects only.

In the next section, "Applied Mechanics," there is much to interest every one: the original models of steam-engines and other machines of Watt; the original models of Stirling's air-engine, and Trevithick's locomotive engine atented in 1802; the "Rocket" and "Puffing Billy," brought out from their retreat in the Patent Office Museum; Brahmah's first hydraulic press; the steam-engine used on Dalswinton Lake in 1788; and the original engine of the steamboat *Comet*. The Royal School of Mines and the Council of

King's College exhibited good collections of models illustrative of the principles of mechanics, and some equally good models come from Germany. Among the specimens of naval architecture are models of the *Faraday*, the *Staunch* gunboat, and the *Castalia*; and beyond these, in the passage leading to the western courts, will be found an interesting collection, exhibited by the Trinity House, under the sub-head "Lighthouses and Fog-signals." In Section 9, "Magnetism," are some of the apparatus used by Faraday, and the loadstone from which he first obtained the induction spark; apparatus used by De la Rive; the greatest natural magnet known; self-registering instruments from Kew, and instruments exhibited by the Admiralty, among which are patterns of those issued to the Arctic Expedition. In Section 10, "Electricity," the special collection sent by the Postmaster-General to illustrate the history of electric telegraphy will attract attention, and so will the original apparatus used by Faraday and by De la Rive. Other objects of interest are Nairne's early electrical machine; Armstrong's hydro-electric machine; Gramme's magno-electric machine; Cooke and Wheatstone's first working telegraph; the instruments used in the Atlantic Cable Expeditions of 1853 and 1866; the original Wheatstone Bridge; copies of the first German telegraphic apparatus constructed in 1809, of the first needle telegraph, and of the electro-magnetic telegraph apparatus of Gauss and Weber of Göttingen, made and used from 1833 to 1838; and a polar-light apparatus by Professor Lemström.

Under Section 1, "Arithmetic," will be found an old calculating-machine invented by S. Morland, and made in 1664; two machines designed by Lord Mahon, and made in 1775–77; the portion of Babbage's calculating machine put together in 1833; the "Napier Bones," made about 1700, and used by the originator of logarithms for performing division and multiplication; Sir William Thomson's tide-calculating machine; and several calculating-circles from Germany. In Section 2, "Geometry," there are many good drawing-instruments and models; and in Section 3, "Measurement," an interesting collection of standard measuring-apparatus, contributed by the Standards Department of the Board of Trade. In the latter section are also Whitworth's delicate measuring-instruments, by which differences of one ten-thousandth and even of one-millionth of an inch can be appreciated, and his new hexagonal surface plates; here, too, are Joule's apparatus; contributions from the Geneva Association for Constructing Scientific Instruments; Boulengé's electric chronograph; Bashforth's clock-chronograph; and, among the instruments for measuring time, a watch which was twice carried out by Captain Cook, and again by Captain Bligh in the *Bounty*, on which occasion he accompanied the mutineers to Pitcairn's Island, and finally, after many vicissitudes, returned to England in 1843. In Section 4, "Kinematics, Statics, and Dynamics," is a collection of Gravesande's apparatus, and a series of Kinematic models exhibited by the K. Gewerbe-Akademie, Berlin. In the northern portion of the west gallery the classification of the catalogue has hardly been followed, and the objects exhibited are grouped more with reference to the purpose for which they are employed: thus astronomical instruments, meteorological instruments, land survey instruments, mining survey instruments, naval survey instruments, and apparatus used in deep-sea exploration, each

form separate groups. This section of the collection possesses so many objects of interest that it is hardly possible to do justice to it in a short notice, and we can only enumerate some of the most important, which will be found in the catalogue under Sections 11, 14, 15, 16. These are: an astrolabe of Sir Francis Drake; a quadrant of Tycho Brahe; Newton's telescope; a quadrant of Napier; a transit instrument made by Lingke, of Freiberg; a telescope by Huyghens, and eye-pieces ground and polished by him; Sir W. Herschel's 7-foot telescope, and his 10-foot Newtonian reflecting telescope; the Galileo and Torricelli relics from Florence, including two telescopes made by the former; Baily's apparatus; Gauss' pendulum for demonstrating the rotation of the earth; Gravesande's heliostat; a complete Transit of Venus equipment; Colby's compensation-bars used in the measurement of the basis in the north of Ireland in 1827 and on Salisbury Plain in 1849; Ramsden's 36-inch theodolite and his smaller 18-inch one, which was set up over the cross at St. Paul's Cathedral; the surveying instruments in use on the Prussian survey; instruments and apparatus used by H.M.'s ships in deep-sea exploration; mining instruments; and a fine collection of meteorological instruments. In Section 15, "Geography," may be noticed some of Livingstone's instruments; MS. plans of Livingstone, Burton, Speke, Grant, and Stanley; MS. journals of Cook, Franklin, and Parry; the log of the *Bounty*; the Ordnance Survey collection of maps; specimens of the survey of Palestine; and some good models of ground. In Section 16, "Geology," will be found the apparatus employed in Sir James Hall's celebrated experiments; specimens of the work of the Geographical Survey; illustrations of the Sub-Wealden boring; original sketches by Dr. Buckland; Davy's safety-lamp; and the latest improvements in goniometers. In Section 18, "Biology," are Van Leuwenhoek's microscope; Van Musschenbroek's microscope; the instruments used by Hooker, Dawson, Turner, and Brown, and the instruments recently described by the Rev. Mr. Dallinger, in the *Monthly Microscopical Journal*; and apparatus used in the several branches of physiological research. In Section 13, "Chemistry," are the apparatus employed by John Dalton in his classical researches; balances used by Sir Humphry Davy and Dr. Joseph Black; Faraday's apparatus for the condensation and liquefaction of gases; Dr. Andrew's apparatus for proving that ozone is a condensed form of oxygen; and a collection from the Master of the Mint, illustrating the processes of gold and silver assaying, including an old cupellation furnace supposed to have been used by Sir Isaac Newton. The collection of physical apparatus is of very great interest; under the head of "Molecular Physics," Section 5, are a small model of Colladon's new air and gas compressors used for the St. Gothard Tunnel; Von Guericke's air-pump and the two celebrated Magdeburg hemispheres exhibited at Ratisbon in 1654; the first air-pump with two barrels; Thilorier's apparatus for liquefying carbonic acid; the apparatus employed by Dr. Andrews in his researches on the continuity of the gaseous and liquid states of matter; and a series of diagrams illustrating the improvements made in the air-pump. Under "Sound," Section 6, will be found the apparatus employed by Colladon in 1826 for ascertaining the velocity of the transmission of sound through water; the double-siren used by Helmholtz in his researches on sound; Le

Roux' apparatus; the first obliquely-strung upright piano patented by Wornum in 1811; models of ancient Egyptian pipes; Tyndall's apparatus; and a stand of apparatus illustrating the progress of Æolian principles. In Section 7, "Light," are: Sir David Brewster's early stereoscope; a camera obscura of Sir Joshua Reynolds; the original form of Brewster's kaleidoscope made in 1815; spectroscopic apparatus used by Sir John Herschel; a fine collection of spectroscopic instruments by Browning and others; Wheatstone's polar clock; Crookes' radiometers; the first photograph taken on glass by Sir John Herschel; the second daguerreotype, a view of the Palais d'Orsay, taken by M. Daguerre in 1830; Herschel's experiments on the action of light on different kinds of salts; and the results of Dr. Forel's experiments in the Lake of Geneva on the penetration of the sun's rays in the waters of the lake. In Section 8, "Heat," may be noticed the original Lavoisier calorimeter, the apparatus used by Professor Tyndall in his researches on the absorption of radiant heat by gases and vapours; Wedgwood's pyrometer; a Musschenbroek's pyrometer; Siemens' pyrometer; apparatus used by Tyndall, De la Rive, and others; and a very fine collection of thermometric instruments.

SCIENTIFIC SUMMARY.

ASTRONOMY.

THE SUN.—Secchi has published a report on solar phenomena during the second half of the year 1875. He finds a *minimum* of activity, the culminating epoch of which would be in March 1876. The number of protuberances has been very varying, from 2 or 3 one day to 10 or 12 the next. The jets of hydrogen were usually straight, even if attaining 2′ or occasionally 3′ in height; an indication of great tranquillity. The chromosphere was low at the equator, but often very elevated (24″ to 30″) at the poles, from the displacement of *maxima* in that direction.—We are sorry to find that the Solar Observatory at Bothkamp has ceased to exist, the Director, Dr. Vogel, having accepted a post at the new observatory of Berlin. Dr. Lohse, whose work has been published together with Vogel's, thinks there is evidence of a subordinate period of 50 days in the eruptive action of the sun. From the drawings of the Spectroscopic Society of Italy he has made out a curve determined by the times of observation combined with the area of the protuberances, and found that, besides *maxima* and *minima* corresponding with those of the spots, it showed a well-marked period of 50 days during 1871, 1872, and the beginning of 1873; but subsequently the whole solar activity became so small, from the 11-years' period, that these secondary *maxima* became undistinguishable. From spectroscopic observations Lohse is led to infer that the electro-negative elements which are not traceable in the sun may exist in the outer layers of the corona. He finds many of the as yet unknown dark lines in the more refrangible end of the solar spectrum, in that of *a Herculis*, and also, though feebler, in that of *Betelgeuse*; but they are not perceptible in *Arcturus*.—Lord Lindsay has presented to the Royal Astronomical Society four folio and ten 4to. MS. volumes, containing the very valuable series of sun-spot observations by the late Mr. Carrington, between 1853 and 1871, which was used for determining the present received values of the position of the solar axis and the drifts in the photosphere. They were recently bid for at an auction by the Society, but purchased by a bookseller, from whom Lord Lindsay subsequently obtained them.

Venus.—It is to be hoped that advantage has been taken of the favourable situation of this lovely planet, to investigate the markings of her surface, and the irregularities of her terminator. These were once the subject of considerable discussion between Schröter and Sir W. Herschel,

and, on the part of the latter, of some little asperity; after which the enquiry seemed to languish till it was taken up by De Vico, but still left in a position hardly corresponding with our advance in the knowledge of most of the other planetary surfaces. There is no doubt considerable difficulty in the investigation; and failures, even with large and powerful instruments, have been numerous. No question, however, exists as to the occasional visibility of brighter specks, and still more frequently of dusky shadings, which stand on multiplied testimony; and there is no adequate reason for not adopting the numerous representations given by De Vico and his associates at Rome, from their observations between 1839 and 1841, with a $6\frac{1}{4}$-in. object-glass by Cauchoix, and in a sky of whose pellucid clearness we can form very little idea in the perturbed and agitated condition of the English atmosphere. It seems strange, however, that these results should never have been verified at the same observatory with the very superior $9\frac{1}{3}$-in. Merz achromatic in the hands of so eminent an astronomer as Secchi; nor have they, so far as we are aware, ever been continuously investigated elsewhere. It is very true that the enlarged apertures of the present time, however keen in definition, are baffled to a great extent by the intense glare of this vividly reflective globe; but it is no less true that this disadvantage might be obviated by the use of a pale screen-glass, or by employing the hours of daylight, which indeed De Vico found alone suitable for his purpose. And where there are so many instances of the occasional detection of these spots, even with very small apertures, there is much encouragement for the perseverance of amateurs.

The Recent Transit.—The reduction of the English observations is proceeding vigorously under the superintendence of Captain Tupman. The amount of work involved has been marvellous. About 5,000 transits of stars were taken for the correction of clock and instrumental errors. The longitudes of the stations at Mauritius and Rodriguez were measured from Suez by Lord Lindsay with fifty chronometers; and Mr. Burton has made more than 6,000 microscopic measures to determine the optical distortion of the photo-heliographs. It is self-evident that a considerable time must elapse before the final result, even of the British observations, can be made known; and it is not as yet decided whether a separate value shall be deduced from these, or whether they are to be combined with the results of all other nations.

The Moon.—The investigation of the surface of our satellite, if we may judge by the number of published observations, makes no very rapid advances, and seems to be little attended to at the principal European observatories. Several amateurs, however, are doing good service in working out details. Many interesting points remain to be discussed as to the probable mode of formation of the lunar surface; in fact, very little has hitherto been done in what may be termed selenology. The materials are as yet not very abundant, but sufficient perhaps for a rough draught, which would be tested and corrected by future observation. There can be little reason for doubting that the key to the lunar configurations lies in the analogy of the eruptive processes of the earth; but important modifications would necessarily be introduced by the dissimilar conditions of the two globes—by the great difference in the force of gravity, in atmospheric

pressure, possibly in internal temperature, and even in the cohesion and fusibility of materials; for though there is certainly every probability in favour of the assumption that the earth and her companion are identical as to composition, it cannot be considered as absolutely demonstrated, or perhaps demonstrable. The supposition that the same elementary forms prevail throughout the solar system has been rendered indefensible by spectroscopic enquiry. Not to insist on minor planetary differences, which as yet may be uncertain in their indication, unsolved mysteries yet hang around the central region of light and fire, and the two outermost planets; of which, prior to the introduction of spectrum-analysis, the telescope could give no kind of information. However, in dealing with selenological enquiries, we can make no other assumption but that of identity with terrestrial materials; and we should only be justified in abandoning it by difficulties on that hypothesis insuperable.

Whatever may be the theories of modern geologists, or whatever changes may yet await some of their conclusions, one thing seems evident, that the eruptive force which has moulded the surface of the moon into its present strange configuration has been decaying down to either comparative or absolute extinction. It is certainly not very material whether our generation may be contemporary with its expiring efforts, or with a subsequent state of quiescence; but it is a question not without much interest; and few observers would not hail with pleasure an opportunity of witnessing the activity of a lunar volcano. However, it is still *sub judice* whether anything of the kind has occurred since the invention of the telescope; and there is more difficulty than might be supposed in forming a reliable opinion, partly from the inaccuracies and mistakes of the earlier observers, partly from the deficiencies of existing maps, and partly from the backwardness to supply those deficiencies at the hands of the possessors of the powerful instruments of the day. Close investigation and careful drawing is required, and that under several angles of illumination; and though photography may render most important service, as that of an eye which never omits anything, yet the circumstances would be very exceptional which would give to its renderings the keenness and certainty of ocular inspection. Each mode may help the other. It is of course among the minutest craters, and, according to that great authority Schmidt, among the fissures or cracks, that we must seek for the evidence of remaining chemical life. But change of perhaps a less intelligible nature may be detected among the multitude of light-streaks and brilliant patches which variegate the fully-enlightened moon with such perplexing intricacy. There is strong evidence of altered brightness in some places, and it is much to be wished that some careful, patient observer would undertake the task of giving us a portion at least of a map of the full moon.

Mars.—The next opposition of this planet in 1877 will, it is believed, give a very reliable value of the solar parallax; and the Astronomer Royal has prepared a chart of stars suitable for comparative observation.

The Minor Planets.—In the "Berliner Astron. Jahrbuch" for 1878 Professor Tietjen has published the approximate places of 144 of the 160 small planets for the present year, and accurate opposition ephemerides of 71.—*Flora.* From corresponding observations of this body in 1873, 41

in the N. and 40 in the S. hemisphere, Galle has deduced a value for the solar parallax of 8″·873.

Jupiter.—Flammarion has made an extensive series of observations on the satellites. He thinks that his results show a difference in their intrinsic nature. IV is less luminous, though larger, than I and II, and very variable, from 6 to 10 mag., probably not from permanent spots, but atmospheric changes. III seems invariable, at 5·9 mag. I and II are about 6·8 and 7 mags., both slightly variable and very white. I can be seen by day, when IV is invisible. Daylight alters the relative lustre, the size of the larger discs gaining by night. I has sometimes appeared smaller than II. Reduced to equal surfaces, the light would stand I, II, III, IV; sometimes II brighter than I. Order of variability, IV, I, II, III. There is some evidence that the changes in IV may arise in part from its always turning the same face to the primary; but its brightness appears complicated with atmospheric disturbance.

Saturn.—A series of micrometrical measures of the satellites has been made with the Greenwich 12¾-in. equatorial.

Uranus.—Mr. Isaac W. Ward, of Belfast, appears to have repeatedly succeeded in glimpsing by averted vision the two brighter satellites with an object-glass of only 4·28 inches by Wray, the estimated positions being subsequently found very fairly accordant with those in Marth's tables. Webb also believes that he has caught sight of *Titania* with a very fine 9·38 silvered glass "With" speculum.

Stars and Nebulæ.—Baron Dembowski has been continuing the measures of double stars, which have for many years given him a high pre-eminence among observers. The following periods of revolution which he has adopted for comparison may be found of use:—ζ *Herculis* (Dunér), 34·22 years. η *Coronæ* (Wijkander), 41·58 y. ξ *Scorpii* (Thiele), 49·05 y. ξ *Ursæ Maj.* (Hind), 60·68 y. ζ *Cancri* (O. Struve), 62·4 y. 70 *Ophiuchi* (Schur), 94·37 y. Σ 3062 (Schur), (112·64 y. ξ *Bootis* (Hind), 168·9 y. γ *Virginis* (Thiele), 185·01 y. δ *Cygni* (Behrmann), 415·1 y. *Castor* (Thiele), 996·85 y. Σ 634 = 19 *Camelopard.* Hevel = P IV 269. This pair is called by Smyth an elegant object, 5½ and 9 mags. light yellow, pale blue. The components are certainly in motion, having been, according to Σ, nearly 37″ apart in 1827, but now only about 20″. O. Struve considers it undecided whether this approach may be due to opposite proper motions or orbital connection: he thinks they may be at a comparatively small distance from us, and may show a sensible parallax, for which the pair is very favourably situated.

Sirius.—Mr. Erck has observed a considerable diminution in the angle of position of the *comes.* Auwers has computed a period of 49·399 years, but the agreement is latterly less satisfactory. 303 double stars have been measured with the 8¼-in. Alvan Clark refractor at Rugby. *Algol.*—Schönfeld has combined 55 observations of *minima* of his own with 183 by Schmidt, and 50 by Argelander, all between 1846 and 1875. The resulting period is 2·867288 days, probable error ± 7m. The most probable duration of the variation, from 2·2 to 3·7 mag., is 9¼h., diminishing most rapidly 1h. 26m. before *min.*, and increasing most perceptibly at an equal brightness 1h. 47m. after *min.* Dr. Schjellerup has published a translation of the Arabic "Description of the Fixed Stars," by Abd-al-

rahman al-Sûfi, in the tenth century, who evidently observed their magnitudes with minute exactness; so that his labours are unrivalled even to the epoch of Argelander's "Uranometria Nova." Dr. Schjellerup has given a very interesting comparative table of the magnitudes of the principal stars, from Ptolemy, Sûfi, and Argelander, which shows that on the whole they are as accordant as could be expected.—Observations of the nebulæ, and measurements of the positions and distances of neighbouring nebulæ and stars, have been continued at Parsonstown.—The original telescopes of Galileo have been sent over from the Florentine Museum to our Scientific Loan Exhibition.—Colonel Cooper's Observatory at Markree, containing the great 13·3-in. Cauchoix achromatic, which has been long suffering greatly from neglect and decay, is now being restored as far as possible under the care of Dr. Doberck, and good work may be expected from it.

BOTANY AND VEGETABLE PHYSIOLOGY.

The Growth of the Male and Female Flowers of Valisneria Spiralis.—In reference to a note on this subject in our number for April, Mr. W. Morrison, the Honorary Secretary of the Dundee Naturalists' Society, sends us the results of some experiments that were conducted by Mr. J. Hood, one of the Vice-Presidents of that Society. He says: "The plants have been in cultivation since 1865, and during that time there have been female flowers four seasons and male flowers on two seasons; the latter in the years 1869 and 1875. The plants continued in flower from June to about the middle of August. The male flowers, including peduncle, never exceeded $1\frac{1}{2}$ inches in length, and the length of the portions above the soil ranged from $\frac{3}{8}$ to 1 inch. From their shortness they may sometimes escape observation. The results of the observations on the rapidity of growth in female flowers were:—

1875								
June 30	8 P.M.	measured plant, and found it to be 2 inches in length						
July 1	9·30 A.M.	increase	$11\frac{7}{8}$	inches	in	$13\frac{1}{2}$	hours	
„ „	8 P.M.	„	$6\frac{5}{8}$	„	„	$10\frac{1}{2}$	„	
„ 2	9·30 A.M.	„	11	„	„	$13\frac{1}{2}$	„	
			$31\frac{1}{2}$			$37\frac{1}{2}$		

The observations were not continued further. It will be seen that the flower increased in length $29\frac{1}{2}$ inches in $37\frac{1}{2}$ hours, and that the increase was much more rapid by night than during the day. Seedling plants are growing in the aquarium from last year's seed."

Experiments on the Digestive Power of Plants.—It is stated by a contemporary that Dr. M. T. Masters has been experimenting on the functions of the nectaries formed by the small cup-shaped petals of *Helleborus*, and finds that they absorb or digest nitrogenous substances, repeating in all respects the phenomena of the leaves of *Drosera* and *Dionæa*.

The Zanzibar Copal and the Copal-tree.—A very interesting paper was that recently read before the Linnean Society (April 20) on this subject. It was a letter from Dr. Kirk, of Zanzibar, which was read by Dr. Hooker. It referred to the identification of the modern copal-tree, *Trachylobium Hornemannianum*, with that which yielded the Zanzibar Copal or Gum Animi, now found in the earth on the East Coast of Africa, and often where no copal yielding tree now exists. Little doubt now rests as to the identity of the semi-fossil with the living tree, inasmuch as bijugate leaf, flower-bud, flower, ovary and stamens, characteristic of the latter, have been discovered in the so-called Animi. Dr. Kirk is inclined to account for their difference in quality by a molecular or chemical change in the buried material; improving it thereby, and as a consequence increasing its market value.

Floral Æstivations.—At the meeting of the Linnean Society (June 1, 1876), the Rev. G. Henslow read a paper on "Floral Æstivations," in which he explained the origin of eight kinds, more particularly referring to the new term "half-imbricate." This latter he applied to a large number of cases ranging from perfectly regular to extremely irregular and zygomorphic flowers of the pea and snapdragon. The author added a note on a new theory of the cruciferous flower, based on a quinary type. He also disputed the tenability of Chorisis in the pairs of long stamens, regarding their occasional union as indicative of evolutionary advance and not retrogression; as cohesion is a subsequent stage to freedom, except in the rare cases of atavism indicated by solution and dialysis. The justness of Pfeffer's view of the corolla of *Primula* being an outgrowth of the androecium he calls in question, giving several reasons in support of this adverse opinion.

African Coffee-plants.—A paper was read before the Linnean Society (April 20), on the African species of the genus *Coffea*, Linn., by Mr. W. P. Hiern. As now restricted this genus belongs to the Old World, attributed American species being referred to other genera. Out of seven Indian species one formerly was cultivated, but has been superseded by African plants. The author distinguishes thirteen species as indigenous to the African continent, and two to Mauritius and Bourbon. Of the former, two kinds are found in East and Central Africa, the remainder ranging along the West Coast. The ordinary commercial coffee, he shows, grows wild in Abyssinia and other parts of Africa; and as to the celebrated Mocha coffee, he regards it as but a doubtful variety of the ordinary sort. A technical description is for the first time given of Liberian coffee, *C. liberica.* This only recently has acquired importance, having been introduced into England in 1874 by Mr. W. Bull, the horticulturist. Already, however, its fame is spreading far and wide among coffee-planters, especially those of Ceylon. Its introduction there has been regarded as a great boon, and justly so; its qualities far surpassing any kind hitherto known. This undoubted distinct species of coffee is robust, hardy, and very productive. It is large-leaved and big-berried, and the latter in flavour and aroma are very superior to the common *C. arabica.* As it thrives at lower altitudes and in districts inimical to the latter, its commercial importance hereafter is likely to be very great. Other useful qualities attributed to it time and experience may test.

Peculiar Food of Ants.—Mr. Francis Darwin read a paper "On the Glandular Bodies on *Acacia sphærocephala* and *Cecropia peltata*, serving as

Food for Ants." The structures in question were discovered by Mr. Belt (Nicaragua), and subsequently further observations made by Fritz Müller (Brazil), while Mr. Darwin has more particularly entered into their minute composition. In *Acacia* they are of two kinds, small, somewhat flattened, pear-shaped bodies, which tip six or seven of the lowermost leaflets of the bipinnate leaves. In *Cecropia* cylindrical bodies are developed in flat cushions at the base of the leaf stalk. Mr. Darwin shows the microscopic structure in all of these to be homologous in kind, cellular, protoplasmic, and containing oil-globules. He infers, moreover, they bear a relation to the serration-glands of Reinke, in certain cases afterwards being converted into stores of nutriment, which undoubtedly the ants live on, and in their turn protect the trees from the ravages of the leaf-cutting ants.—Linnean Society, June 1.

Pythium Equiseti.—Great interest is just now attached to this curious parasite, and hitherto it has not been recorded as British. Dr. Sadebeck, of Berlin, described the plant last year as a new species of Pythium, parasitic upon *Equisetum arvense.* Mr. W. Smith says ("Gardener's Chronicle") it bears a considerable resemblance to the bodies discovered last year, and referred by me to the secondary condition of the potato fungus. It ultimately appeared that Dr. Sadebeck also last year found a similar parasite infesting and destroying living potato plants near Coblenz, and at the time he referred the Equisetum and potato parasites to the same fungus, and on seeing my micro-photographs he doubtfully threw out the suggestion that all three fungi might possible prove to be the same with each other. On these insufficient grounds a report was spread in this country that the organisms described by me were the same with Dr. Sadebeck's Pythium Equiseti, and the "Journal of Botany" for March last stated, in reference to Pythium Equiseti, that it had "lately been attempted to connect this fungus with the oospores of *Peronospora infestans.*" Dr. Sadebeck can hardly be said to have made such an attempt, for in a very kind letter that he wrote me on March 23 last he said the presumed identity was a mere "supposition," thrown out in a preliminary paper, that he was without experiments from which to form a definite conclusion, and that he had not been able to infect the potato plant artificially with the Pythium. Dr. Sadebeck's excellent paper, and the evident strong external resemblance of his newly-discovered plant to mine, made me extremely desirous of seeing the Berlin plant, but on writing to Dr. Sadebeck to this effect he replied that he had no specimens. It therefore only remained to look out for the parasite here, and I was fortunate enough to enlist the good services of Mr. B. D. Jackson, F.L.S., who sent me some capital specimens of *Equisetum arvense* from Snodland, Kent, on April 25. The first piece of Equisetum I examined under the microscope displayed the presence of fungus spawn ramifying amongst the tissues; so, from experience gained of the habits of some of the lower fungi, I half submerged the specimens of Equisetum and kept them covered up in a dark place. In ten days the Equisetum plants were dotted inside and out with gelatinous patches, and every patch was a mass of Pythium Equisetum. Though bearing a strong resemblance to the early condition of the bodies found by me in the Chiswick potatos, yet Pythium Equiseti is clearly not the same. Mr. Berkeley, who has seen both plants, writes me that he considers them

"decidedly different." I have been unable to infect the potato plant with the Pythium or the Equisetum with my potato oospores. My experiments, therefore, agree with the results obtained by Dr. Sadebeck, and the two parasites may be considered different.

The Black Knot of Plum and Cherry-trees is the subject of an important memoir, illustrated by plates, in the "Bulletin of the Harvard University." The paper is illustrated by three beautiful plates, showing this disease in various stages, and the whole structure, development, and fructification of *Sphoria mortosa* of Schucinitz, the fungus which produces this black knot, which so deforms and injures plum and cherry-trees throughout the Northern States and Canada. The remedy is the knife or the axe. For prevention Dr. Farlow recommends the extirpation of choke cherry-trees, upon which the pest largely breeds in the vicinity of Boston. Farther west it would all the more be necessary to destroy all the wild plum-trees (*Prunus Americana*), which are fearfully infested.

Mr. Meehan's Explanation of his Attack on Mr. Darwin.—At a recent meeting of the Academy of Philadelphia Mr. Thomas Meehan remarked that the American correspondent of "Nature" had characterised some recent remarks of his on fertilization by insect agency as an attack on Mr. Darwin. He thought the members of the Academy would bear him out in the statement that the facts and observations he had from time to time offered were submitted in no spirit of antagonism to Mr. Darwin, but often favoured as much as they opposed views held by that distinguished gentleman. Even those who were avowed partisans of Mr. Darwin felt it necessary to strengthen their position by searching for new facts. Surely the mere student, who was willing to wait till the evidence was all in, might offer the facts as he found them, without being liable to the charge of direct antagonism.

CHEMISTRY.

Detection of Chicory in Coffee.—Professor Wittstein, who has a long paper on the adulteration of coffee in the "Chemical News" (May 12), states that Mr. J. Horsley, some time ago, proposed the following process for the detection of chicory in coffee:—If to a much diluted decoction of chicory a solution of bichromate of potash be added, no sensible reaction will take place. If, however, we subject to this same reagent a decoction of pure coffee, its colour will immediately darken, and become brown similar to porter. This is, therefore, an easy method of distinguishing between the two, provided they are separate. In mixtures the determination of the impurity becomes much more difficult. In this case a dilute decoction is made of a weighed quantity of the suspected mixture. It is then to be heated to boiling and treated with the solution of bichromate of potash. A few decigrammes of copper sulphate are next added, and the solution is again to be boiled, whereupon a dark brown flocculent precipitate will be formed. The depth of its colour depends on the quantity of coffee in the mixture; and we have thus, by comparing this precipitate with a similar one of the same

quantity of pure coffee, an approximate method of examining our mixture quantitatively.

The Reaction of Biliverdin.—This is a subject to which Dr. Thudicum has recently been devoting his attention. He read a paper upon it at the meeting of the Chemical Society on May 4. After stating that the cause of the yellow colour of the skin of persons suffering from "yellow jaunddice" was bilirubin, whilst the dark colour of the so-called "black jaundice" was due to the presence of biliverdin, he proceeded to describe some derivatives of the latter substance. *Monobrominated biliverdin*, $C_8H_8BrNO_2$, was prepared by passing bromine vapour mixed with dry air over finely powdered biliverdin until it ceased to be absorbed, and the product was then heated to 100°C. in a current of dry air. It is a black powder, insoluble in ether, and very little soluble in alcohol. It is soluble in sulphuric acid, but is precipitated on dilution with water. It is soluble in caustic soda, being precipitated again in brown flocks by acetic acid. *Hydro-biliverdin* is formed on treating a solution of biliverdin in dilute caustic soda with sodium amalgam. It dilutes alcoholic solution, gives a spectrum showing an absorption-band overlying the line F equilaterally, and totally different from the broad band between E and F shown by solutions of hydro-bilirubin. We are not quite prepared to accept Dr. Thudicum's views as to the pathology of the disease.

The Manufacture of Sulphuric Anhydride.—A paper on this important practical subject was read by Dr. W. Squire before the Chemical Society on April 20. Dr. Squire, after giving a sketch of the history of the manufacture of sulphuric acid, described the process for preparing the anhydride. The vapour of ordinary sulphuric acid is passed through a white-hot platinum tube, whereby it is almost completely decomposed into water, oxygen, and sulphurous anhydride: the mixed gases, after passing through a leaden worm to condense the greater portion of the water, are completely dehydrated in a leaden tower filled with coke, over which a stream of concentrated sulphuric acid is allowed to trickle. The dry mixture of oxygen and sulphurous anhydride is now passed through platinum tubes heated to low redness, and containing fragments of platinised pumice, when the gases recombine to form sulphuric anhydride, which is condensed in a series of Woulffe's bottles.

Experiments on the Sugar Beet have been lately carried out by MM. Fremy and Dehérain, which show (Comptes rendus, April 24) that saline solutions identical in composition act very differently upon beets accordingly as the roots plunge into the solutions themselves, or as the latter merely occupy the pores of the soil. On planting beets of different origin in identical conditions as to soil, manure, and watering, roots are obtained differing in their yield of sugar. An excess of nitrogenous manure lowers the percentage of sugar in all beets, but those of a superior strain preserve still such a quantity of sugar that they may be advantageously treated. To produce from a given surface the maximum of sugar under conditions advantageous alike for grower and manufacturer, we must depend above all on a judicious selection of the seed.

Calcareous Alabaster from Mexico.—M. A. Damour says, in a paper read before the French Academy, on May 8, and quoted by the "Chemical

News," May 19, that this material is known in commerce as the onyx of Tecali. It varies in colour from milk-white, yellowish white to pale green, certain samples displaying brown veins shading into red. It takes a fine polish. Its specific gravity is 2·77. It is readily and entirely soluble in nitric acid. Its composition is—

Carbonic acid	43·52
Lime	50·10
Magnesia	1·40
Ferrous oxide	4·10
Manganous oxide . . .	0·22
Water	0·60
Silica	traces
	99·94

Sulphur in Coal Gas.—M. A. Virigo states that ("Chemical News," May 12) he found, in portions of 100 cubic feet of gas made at Odessa, respectively 2, 1·81, 1·9, 2·01, and 2·2 grms. of sulphur. He readily detected the presence of sulphurous acid in the air of rooms lighted with this gas, and demonstrates its ready conversion into sulphuric acid in contact with moist organic matter, such as cotton yarn.

Experiments as to Insecticides on the Phylloxera.—M. Dumas' book on this subject has been published, and has been reviewed in the "Chemical News" of May 2, from which we take the following remarks:—"As regards the phylloxera of the roots it is found that the sulpho-carbonate of potassium, of which more than 20,000 kilos. have been already used, is a rapid insecticide, the only one which certainly destroys the phylloxeras fixed upon the roots, and which affords at the same time an efficient nourishment to the vine. The sulpho-carbonate of sodium offers similar advantages as an insecticide only. The sulpho-carbonate of barium being an anhydrous salt, and sparingly soluble, is recommended by its resistance to the action of oxygen and to that of carbonic acid, which renders it a poison less rapid, but of an effect more durable. As to the winter-eggs the heavy oil of gas-tar, and especially the so-called oil of anthracen, seems to be the most suitable agent for anointing the branches and for destroying the winter-eggs. The application of gas-tar to the branches and of sulpho-carbonates to the roots is best performed in the months of February and March.

Death of Dr. Letheby.—The "Analyst" says: "We have to announce, with deep regret—a regret which will be shared by our readers—the death, somewhat suddenly, of Dr. Letheby. He had been unwell for some weeks, his complaint being, we believe, inflammation of the lungs. Dr. Letheby was too well known in the chemical world to require any lengthened obituary notice at our hands. We may, however, mention that he was an early member of the Chemical Society; that he took his M.B. degree in 1843, became Ph.D. and M.A. in 1858; that amongst the numerous appointments which he had held were those of Medical Officer of Health and Public Analyst for the City of London; and that he was the author of numerous scientific and hygienic works. He died in his sixtieth year."

The Production of Bromine in America.—The "American Journal of

Pharmacy" states that bromine was produced in America as early as 1846, for photograph purposes. With the decline of the daguerreotype process the manufacture of bromine also ceased. In 1866 the employment of bromides in medicine renewed this branch of industry, the element being obtained from the mother liquors of the salt-works at Tarentum and Natrona in Alleghany. In 1868 an increasing demand led to its production in Pennsylvania, Ohio, and Western Virginia. Between the years 1867 and 1873 the amount produced rose from 5,000 to 88,000 kilogrammes. Up to the year 1870 the yield merely sufficed to supply the demands of the United States, and during that year bromine was first exported. Since that date the amount produced has steadily increased, and has so largely exceeded the demand that no new factories are now erected.

GEOGRAPHY.

Return of Lieutenant Cameron.—At the meeting of the Royal Geographical Society, which took place on April 11, Lieutenant Cameron was gallantly received. The meeting was held in St. James's Hall, which was crowded by a large and fashionable audience. The chair was taken by H.R.H. the Duke of Edinburgh, who in the course of his opening remarks congratulated the navy on the fact that a member of it should have accomplished so great a feat as Cameron's journey from sea to sea was. Lieutenant Cameron then gave a brief *résumé* of his journey from the East Coast to Ujiji, and thence across Lake Tanganyika to the West Coast. The main features of this narration have already been made known to the public through the pages of the "Geographical Magazine" and "Proceedings" of the Royal Geographical Society. Regarding the interesting question of the outlet to Tanganyika, he stated that there was no place to which the Lukuga could flow except into the Lurwa, and that native information corroborated this view. Apart from the great difference between the volume of water of the Lualaba at Nyangwe and that of the Nile at Gondokoro, the levels proved conclusively that the two rivers could have no connection. He had seen a good deal of the slave-trade, and observes that the Portuguese are the principal agents in the trade, the Arabs as a rule buying only enough slaves to act as porters and servants. The only effectual way of putting an end to slavery was to open up Africa to legitimate commerce by utilising the magnificent water-systems of the interior. Sir Henry Rawlinson expressed, on behalf of the council of the Society, a high opinion of Cameron's services, which, besides their geographical importance, were equally interesting to the politician, the merchant, and the philanthropist. He had been almost continuously on the tramp for two years and eight months, during which he had been exposed to every kind of hardship, and had travelled over 3,000 miles. His observations, which numbered over 5,000, were copious, elaborate, and accurate. Among the most noticeable of the results of his expedition were his exploration of the southern half of Lake Tanganyika and his discovery of the outlet, and his demonstration of the probable identity of the Congo and Lualaba. Another important result

was the discovery of a new political power, that of Kasongo, apparently the greatest chief in equatorial Africa. Any measures for suppressing the slave-trade would probably be carried on through his agency. Lieutenant Cameron had tracked the atrocious traffic in slaves to its fountain-head, and had thus rendered a great service to civilisation as well as to geography. In conclusion, Sir Henry announced that the council of the Society had awarded the principal gold medal of the year to Lieutenant Cameron. After a few remarks from Dr. Badger and Sir Alexander Milne, the latter of whom pronounced Lieutenant Cameron to be a credit to his profession, H.R.H. the Duke of Edinburgh moved a vote of thanks for the paper, and the meeting broke up.

GEOLOGY AND PALÆONTOLOGY.

Relations between Reptiles and Mammals.—Professor Owen has lately described a carnivorous reptile, named by him *Cynodracon major*, which has the compressed sabre-shaped canines of the lion of the genus *Machærodus*, and resembles carnivores both in the canines and incisors. In the lower jaw the bases of eight incisors and of two canines (very inferior in size to the canines of the upper jaw) are visible, and the canines are separated by a gap from the incisors. In this character, as in the number of incisors, the fossil resembles a *Didelphys*. The left humerus is 10½ inches long, but is abraded at both extremities; it presents characters—in the ridges for muscular attachment, in the provision for the rotation of the forearm, and in the presence of a strong bony bridge for the protection of the main artery and nerve of the forearm—which resemble those occurring in carnivorous mammals, and especially in the Felidæ, although these peculiarities are associated with others having no mammalian resemblances. Professor Owen discusses these characters in detail, and indicates that there is, in the probably Triassic lacustrine deposits of South Africa, a whole group of genera, many represented by more than one species, and all carnivorous, which have more or less decided mammalian analogies; and to them he gives the general name of *Theriodonts*.

The Petrified Forest of California.—At a recent meeting of the Troy Scientific Association, Dr. Ward delivered an address on the Petrified Forest of California. He considered the peculiar fracture of the fallen petrified trunks their most suggestive and important peculiarity, since they are broken up somewhat symmetrically in a manner that might happen to wood rendered brittle by charring or perhaps by partial petrifaction, but could hardly be conceived as occurring to ordinary wood or stone.

The Brain of Dinoceras seems to have been remarkably small. The *Dinoceras*, which has been recently discovered by Professor Marsh in the Eocene beds of Wyoming, nearly equalled the elephant in size, but the limbs were shorter. The head could reach the ground, and there is no evidence that it carried a proboscis. Professor Marsh figures the skull in his second memoir, entitled "Principal Characters of the Dinocerata." "The brain-cavity in *Dinoceras* is perhaps the most remarkable feature in this remarkable genus.

It proves conclusively that the brain was proportionately smaller than in any other known mammal, recent or fossil, and even less than in some reptiles. It was, in fact, the most reptilian brain in any known mammal. In *D. mirabile* the entire brain was actually so diminutive that it could apparently have been drawn through the neural canal of all the presacral vertebræ, certainly through the cervicals and lumbars."

Remains of Coryphodon and Dinocerata.—The examination of a series of Mammalian remains, obtained from the Eocene deposits of Wyoming, Utah, and New Mexico, has led Professor Marsh to infer that the genus Bathmodon described by Professor Cope clearly belongs to the genus Coryphodon of Owen. This is especially important and interesting, as the geological horizon of the remains is essentially the same in both countries, and the American specimens promise to clear up many doubtful points in regard to the animals themselves. The characters shown in the skull and limbs of Coryphodon indicate that this genus was essentially Perissodactyle, and represents a distinct family which may be called Coryphodontidæ. Professor Marsh has described the principal characters of a well-marked group of gigantic mammals, which are abundant in the lower Miocene deposits on the eastern slope of the Rocky Mountains. These animals, the Brontotheridæ, of which four genera are known, equalled in size the gigantic Eocene Dinocerata, and resembled them in some important features, but differed from them in having but a single pair of horn cores and no crest around the vertex; the structure and number of the teeth were also quite different, and do not belong to the same order, but constitute a distinct family of Perissodactyles.

Birds with Teeth.—The same author has also given an account of a remarkable group of birds with teeth, obtained from the cretaceous beds of Kansas, where the associated vertebrate fossils are mainly Mososauroid reptiles and Pterodactyls. They constitute a sub-class, Odontornithes, comprising two orders—the *Ichthyornithes*, having the teeth in sockets, biconcave vertebræ, a keeled sternum, and wings well developed, represented by Ichthyornis and probably Apatornis, and the *Odontolcæ*, with the teeth in grooves, the vertebræ as in recent birds, a sternum without keel and rudimentary wings, represented by Hespeornis. The occurrence of toothed birds in England has been described by Professor Owen from the London clay of Sheppy.

American Fossil Fishes.—Professor J. S. Newberry has further described the structure and relations of Dinichthys and other fossil fishes from the Devonian and Carboniferous strata of Ohio. The most striking feature of *Dinichthys*, apart from its great size, is the dentition, which is massive and peculiar, and offers some remarkable and suggestive points of resemblance with Coccosteus among fossil, and Lepidosiren among living fishes, besides which there is a singular correspondence between the ventral shields of Dinichthys and Coccosteus. From the examination of a large amount of new material, Professor Newberry remarks that the discovery of Dinichthys is a matter of interest, not simply because it adds another and the most gigantic to a strange extinct group of fishes, but also because it serves as a connecting link between several genera of Devonian Placoderms, of which the affinities have been somewhat obscure, viz. *Coccosteus* and

Pterichthys with *Asterolepis* and *Heterostius*; and more especially because it shows a relationship to exist between these peculiar fishes and the anomalous living *Lepidosiren*, and thus showing that probably a parallel line ran upward from the Devonian Placodenus to the other living branch of the Dipnoan family, now represented by Lepidosiren and Protopterus.

A new Trilobite.—Dr. S. T. Barrett has described, in the "American Journal of Science" (March 1876), a new and interesting form of Trilobite, *Dalmanites dentata*, so named from the peculiar dentate margin of the cephalic shield. Each thoracic segment terminates with a slender terete spine, curved outward and backward. This species is found in the Lower Helderberg formation, near Port Jervis, Orange County. Some of the layers of the rock are mainly made of its remains.

On a Gigantic Bird from the Eocene of New Mexico.—Professor Cope exhibited recently to the Philadelphia Academy of Science a tarsometatarsus of a bird, discovered by himself during the explorations in New Mexico, conducted by Lieutenant G. M. Wheeler, U. S. A. The characters of its proximal extremity resemble in many points those of the order *Cursores* (represented by the *Struthionidæ* and *Dinornis*), while those of the distal end are, in the middle and inner trochleæ, like those of the *Gastornis* of the Paris Basin. Its size indicates a species with feet twice the bulk of those of the ostrich. The discovery introduces this group of birds to the known faunæ of North America, recent and extinct, and demonstrates that this continent has not been destitute of the gigantic forms of birds, heretofore chiefly found in the Southern Hemisphere faunæ.

MEDICAL SCIENCE.

The Physiology of Hearing.—The "Berlin Journal of Chemistry" is responsible for the following facts, which it gathers from a medical journal. It states that Herr Urbantschitch calls attention to the fact that if a watch be held at a little distance from the ear, the ticking is not heard uniformly, but there is a swelling and diminishing of the sound. If held at such a distance as to be scarcely audible, the ticking will come and go, being at times perceived distinctly, but at times becoming wholly inaudible, as if the watch were being moved to and from the ear. This variation in perception is not always gradual; it is sometimes sudden. The same holds good for other weak sounds, as that of a weak water-jet, or a tuning-fork. Since breathing and pulsation have not the least influence on the phenomenon, the interruptions of the sensation must be attributed to the organ of hearing itself; our ear is unable to feel weak acoustic stimuli uniformly, but has varying times of fatigue. To decide finally where the peculiarity lay, M. Urbantschitch made both ear-passages air-tight and applied a tuning-fork and a watch to the head. The sounds seemed not continuous, but intermittent. The cause must therefore be in the nerves of hearing.

The Filtration of Typhoid Germs.—An important letter on this subject, with the general terms of which we entirely agree, has been published in the "Sanitary Record," June 3. Dr. Tripe calls attention to the statements

recently made by Mr. Wanklyn, at the Society of Medical Officers of Health, one of which concerned the purification of water supposed to contain the germs of typhoid fever. The following quotation from Dr. Tripe's letter will fully explain his position and that of Mr. Wanklyn :—"I attended the meeting, but arrived too late to hear Mr. Wanklyn's speech; but was informed that he had stated that the non-detection of albuminoid matter, by Nessler's test, after distillation of filtered water with an alkaline permanganate, was strong proof of the absence of typhoid germs. The issue thus taken is one of the greatest importance, because if Mr. Wanklyn's statement be true, the most polluted water can be rendered potable and innocuous by filtration through a moderately thick bed of filtering materials. Certainly this statement is contrary to the opinions held by most other chemists, and if it be based on the absence of ammonia after distillation of the suspected water with an alkaline permanganate, the assumption is almost certainly erroneous, as Mr. Wanklyn himself admits that all the albuminoid matters are not converted into ammonia by his process. He would appear to have made this statement without knowing the size of the minute organisms which are suspected to be typhoid germs, otherwise he could not have placed any reliance on the Nessler test. Dr. Klein says that they are one-third the size of the blood corpuscles of man, but his engravings show them to be much smaller, and to possess only about one-sixth the area of a blood-disc. Now if they are similar to bacteria in their mode and rapidity of increase, it would be only necessary for a very few to obtain admission into the human body to set up their specific action, provided the person were susceptible to their influence. Does Mr. Wanklyn say that he could detect by the albuminoid ammonia process a dozen of these, which are less than the total bulk of one blood corpuscle, in half-a-pint of water? and if not, where is his argument?"

METALLURGY, MINERALOGY, AND MINING.

Compressed Peat.—"Silliman's American Journal" states that peat pressed into blocks and made so compact that a cubic foot weighs 85 to 100 pounds, is manufactured by Mr. A. E. Barthel, of Detroit, Michigan, and sells for one and a half dollars per ton.

The New Metal Gallium.—At a meeting of the French Academy the Secretary opened a sealed note deposited by M. Lecocq de Boisbaudran, the first paragraph of which reads thus:—"Day before yesterday, on Friday, the 27th of August, 1875, between three and four o'clock in the afternoon, I obtained indications of the probable existence of a new simple body among the products of the chemical examination of a blende coming from the mine of Pierrefitte, valley of Argeles, Pyrenees." The evidence relied on to prove this discovery, a part of which evidence was given in the sealed note and another part in a note read at the same meeting, is: (1) the oxide (or perhaps a basic salt) is precipitated slowly by metallic zinc in a solution containing chlorides and sulphates; (2) its salts are easily precipitated by barium carbonate in the cold; and (3) it gives a spectrum showing two

violet lines of wave lengths 417 and 404 respectively. In all its other chemical reactions it closely resembles zinc; though in the precipitations it has always the preference when these are incomplete. To the metal thus indicated, Lecocq de Boisbaudran gave the name "Gallium." In a more recent paper he gives additional facts regarding the new metal, which he has been able to free almost entirely from zinc.

METEOROLOGY.

The great Iowa Meteor.—An account of this very large stone is given by the "Boston Journal of Chemistry," in the following terms:—"Some time ago a meteor of extraordinary splendour appeared in the heavens, over the State of Iowa, and after dazzling the eyes of all those who were so fortunate as to see it, burst asunder with a loud report, and in a few seconds disappeared. Fragments of this meteoric mass were scattered over a wide extent of country, and more than 700 pounds have up to the present date been picked up by various persons, and sold to geologists, chemists, and others, at high prices. We are under great obligations to C. W. Irish, Esq., civil engineer, of Iowa City, for a splendid specimen of the stone, which he kindly sent to us last autumn. The specimen weighs about 11 ounces, and accompanying it was a small fragment, which was sent for chemical examination. Our time has been so occupied that we have not been able to bestow upon it analytical labour, but intend shortly to do so. We presume, however, that it does not differ essentially from the specimens examined by Professor Henrichs, and we present in tabular form his results:—

Meteorites	Iron	Nickel	Sulphur	Ferrous Oxide	Magnesia	Lime	Silica	Sum
Non-Magnetic:								
Triolite	1·1	—	0·7	(1·5)	—	—	—	1·8
Hyalosiderite . .	—	—	—	15·2	17·5	0·6	19·6	52·9
Hypersthene . . .	—	—	—	8·8	9·7	2·2	24·2	44·9
Loss, traces . .	—	—	—	—	—	—	—	0·4
Sum	1·1	—	0·7	24·0	27·2	2·8	43·8	100·0
Magnetic:								
Nickeliferous Iron .	6·6	0·9	—	—	—	—	—	7·5
Total	7·7	0·9	0·7	24·0	26·2	2·8	43·8	107·5

The stone, in physical appearance, resembles in most respects those which have fallen upon other parts of our planet, but in chemical composition it varies essentially. It is covered with a black crust, formed during the cosmical part of its motion through the earth's atmosphere. This crust, in the view of Professor Henrichs, is not due to fusion, but simply to the heating of the outer layer of the stone to a red heat. The interior is of a greyish colour, and resembles iron stones of terrestrial origin; when exposed to a red-heat the colour is changed to a black like the crust."

A Chronicle of the recent Falls of Meteorites is given in the "Academy," May 13. On Sept. 14, 1875, at 4 P.M., a meteorite fell at Supino, in the district of Frosinone, Italy, of which Keller publishes a short notice in the "Opinione," Sept. 28, 1875. Its descent was accompanied with the hissing noise and explosion usually observed on such occasions. It is stated that the meteorite took an almost horizontal direction towards a house situated in Supino, which, owing to its having a parapet pierced with apertures, it passed without impact, and that it was then lost to sight. Fragments, respectively weighing 364, 199, 29, and 18·5 grammes, were afterwards found. After the lapse of more than 40 years (if we except the curious explosion which took place over Writtle, near Chelmsford, on Sept. 7, 1875, and that over Bradford, on Sept. 15, 1875, when no meteorites were found) a meteorite appears to have fallen in England on the 20th of last month, at Crudgington, near Wellington, Salop, at 3.40 P.M. It penetrated the earth to the depth of 18 inches, and is stated to weigh $7\frac{3}{4}$ lbs. It was exhibited last week, at a meeting of the Birmingham Natural History Society, when a resolution was passed that the meteorite should become the property of the nation, and be submitted to the fullest scientific investigation.

MICROSCOPY.

The Early History of Microscopy.—Dr. H. A. Hagen has a paper in the "American Naturalist" (March, 1876) which, while dealing with a kindred subject, alludes to this. He says it is well known that magnifying-glasses have been found among the Assyrian relics and the ruins of Pompeii, but the use of their magnifying power is nowhere recorded, though it is probable that some of the admirable gems of the ancients were cut with the help of lenses. Spectacles, perhaps in some way known in Rome, and even used by Nero, are said to have been invented at the end of the thirteenth century in Italy. Magnifying-glasses were manufactured by Arabians, and later by Roger Bacon, but certainly not used for the purposes of natural history before the beginning of the seventeenth century. Italy and Holland dispute the honour of the invention, which was perhaps simultaneous in the two countries. The great advantages of lenses for observation were directly acknowledged, and even augmented, by the invention of the compound microscope. Fontana in Rome and Drebbel in Holland are the rival inventors.

Microscopical Papers for the Quarter.—The following is a list of the several papers relating to microscopy that have appeared in the "Monthly Microscopical Journal" for April, May, and June:—

On a New Arrangement for Illuminating and Centering with High Powers. By Rev. W. H. Dallinger, V.P.R.M.S.—The Identification of Liquid Carbonic Acid in Mineral Cavities. By Walter Noel Hartley, F.C.S. (King's College, London).—On some Structures in Obsidian, Perlite, and Leucite. By Frank Rutley, F.G.S. (H.M. Geological Survey).—On the Aperture of Object-glasses. By F. H. Wenham.—On Zeiss' $\frac{1}{25}$th Immersion. By W. J. Hickie, M.A.—Notes on the

Markings of Navicula rhomboides. By Dr. J. J. Woodward, U. S. Army.—Some Results of a Microscopical Study of the Belgian Plutonic Rocks. By A. Rénard, S. J.—A New Microscopic Slide. By M. Ernest Vanden Broeck.—Measurements of Möller's Diatomaceen-Probe-Platten. By Edward W. Morley, Hudson, Ohio, U. S. A.—On the Markings of the Body-scale of the English Gnat and the American Mosquito. By Dr. J. J. Woodward, U. S. Army.—Notes on Micro-photography. By Surgeon-Major Edward J. Gayer, H.M. Indian Army, now Professor of Surgery, Medical College, Calcutta.—On Renulia Sorbyana. By J. F. Blake, F.G.S.—Remarks on Frustulia Saxonica, Navicula rhomboides, and Navicula crassinervis. By Charles Stodder, U. S. A.—On the Measurement of the Angular Aperture of Object-glasses. By Jabez Hogg, Surgeon to the Royal Westminster Ophthalmic Hospital, F.R.M.S., &c.

PHYSICS.

The Waves as a Motive Power.—Mr. B. Tower, who some time since described his method to an English audience, does not appear to have gone on in furtherance of his discovery. His machine consists in principle of a weight supported on a spring, so that it can oscillate on the spring through a considerable range in a vertical line. The scale of the spring, and consequently the natural period of oscillation of the weight, can be varied at will. When it is so adjusted that it synchronizes with the waves, the oscillations become very violent, and a large amount of power can be obtained from them. In practice, the springs consist of highly-compressed air pressing on the rims of hydro-pneumatic cylinders, and the arrangement is such that the vessel containing the compressed air forms the moving weight. At the meeting referred to Mr. Tower exhibited a design of a machine for working an auxiliary propeller of a sailing ship of 1,800 tons displacement. The moving weight in this case is 200 tons, and he showed by calculation that it would give about 30 horse-power in the long swell met with in the tropical calms, 260 horse-power in average ocean waves, and more than 600 horse-power in a heavy head sea. The space occupied by the machine compares favourably with a steam-engine of the same power. He also exhibited a model of the machine, which recently, in a moderate sea, had yielded power at the rate of $1\frac{1}{2}$ horse-power per ton of moving weight.

Experiments on the Periodic Waves of the Swiss Lakes.—At a recent meeting of the Physical Society of London (May 27), Professor Forel, of Morges, Switzerland, gave, in French, an account of some interesting experiments which he has recently made on the periodic waves which take place on the Swiss lakes, and are there called "Seiches." It was long since observed that the waters of most of these lakes are subject to a more or less regular rise and fall, which at times have been found to be as much as one or two mètres. M. Forel has studied this phenomenon in nine different lakes, and finds that it varies with the length and depth of the lake, and

that the waves are in every way analogous to those already studied by Professor Guthrie in artificial troughs, and follow the laws which he has deduced from his experiments. Most of the experiments in Switzerland were made on the Lake of Geneva, but that of Neuchatel was found to be best fitted for the study of the subject, possessing, as it does, an extremely regular geometric form. The apparatus he employed was very sensitive to the motion of the water, being capable of registering the waves caused by a steam-boat half an hour after it had passed, and five minutes before its arrival; and was so constructed as to eliminate the effect of common waves, and to register the motion, side by side, with a record of the state of the barometer, on paper kept in continuous motion. While he found the duration of waves to be ten minutes at Morges it was seventy minutes at Geneva, and this is explained by the narrowness of the neck of the lake at the latter place. This period he proved to be independent of the amplitude, and to be least in the shortest lakes. For shallow lakes the period is lengthened; and his observations show that the period is a function of the length and depth, and that longitudinal and transverse waves may co-exist, just as Professor Guthrie has shown to be the case in troughs.

Imitation Snow Crystals.—M. Dogiel, of St. Petersburg, selects a substance which crystallizes like snow, in a great variety of forms of the hexagonal system. And this substance is iodoform. To show the multiplicity of forms, M. Dogiel dissolves iodoform in boiling (90 per cent.) alcohol, and lets the solution cool in water of different temperatures. He gets mostly tabular crystals, when a solution containing 15 to 30 per cent. of iodoform is kept ten minutes in water of about 14° to 15° C.; whereas star-shaped and often very complicated crystals are had at temperatures of 26° to 37°. Some other modifications of the result are described by M. Dogiel, in a paper recently published, and he also gives drawings of the crystals he obtained.

A Remarkable Atmospheric Phenomenon at Ceylon.—The Rev. R. Abbay sent a communication on this subject to the Physical Society, May 27. In speaking of several of these phenomena he says that the most striking is witnessed from the summit of Adam's Peak, which is a mountain rising extremely abruptly from the low country to an elevation of 7,200 feet above the sea. The phenomenon referred to is seen at sunrise, and consists *apparently* of an elongated shadow of the mountain, projecting westward to a distance of about 70 miles. As the sun rises higher it rapidly approaches the mountain, and appears at the same time to rise above the observer in the form of a gigantic pyramid of shadow. Distant objects may be seen through it, so that it is not really a shadow on the land, but a veil of darkness between the peak and the low country. It continues to rapidly approach and rise until it seems to fall back upon the observer, like a ladder which has been reared beyond the vertical, and the next instant it is gone. Mr. Abbay suggests the following explanation of the phenomenon:—The average temperature at night in the low country during the dry season is between 70° and 80° F., and that at the summit of the peak is 30° or 40° F.; consequently, the low strata of air are much the less dense, and an almost horizontal ray of light passing over the summit must be refracted upwards and suffer total internal reflection, as in an ordinary mirage. On this supposition the veil

must become more and more vertical as the rays fall less horizontally, and this will continue until they reach the critical angle, when total internal reflection ceases, and it suddenly disappears. Its apparent tilting over on the spectator is probably an illusion, produced by the rapid approach and the rising of the dark veil without any gradual disappearance which can be watched and estimated. It will be evident that the illumination of the innumerable particles floating in the atmosphere causes the aerial shadow to be visible by contrast. Another interesting phenomenon visible in the mountain districts admits of an equally simple explanation. At times broad beams, apparently of bluish light, may be seen extending from the zenith downwards, converging as they approach the horizon. The spaces between them have the ordinary illumination of the rest of the sky. If we suppose, as is frequently the case, that the lower strata of air are *colder* than the upper, the reflection spoken of in the case of Adam's Peak will be downwards instead of upwards. If several isolated masses of clouds partially obscure the sun, we may have several corresponding inverted veils of darkness, like blue rays in the sky, all apparently converging towards the same point below the horizon. This latter phenomena is called by the natives "Buddha's rays."

A Simple Form of Heliostat.—The heliostat is such an useful instrument, not merely for the physicist, but for the photographer, that any mode of improving it is of interest. At the meeting of the Physical Society on April 29, the Secretary read a communication from Sir John Conroy, Bart., "On a Simple Form of Heliostat." The defect of Fahrenheit's heliostat, in which the beam of sunlight is reflected by a mirror moved by clockwork in a direction parallel to the axis of the earth, and then in the required direction by a fixed mirror, consists in the great loss of light. The author substitutes two silvered mirrors for the looking-glasses usually employed, and he has shown that the loss of light with this arrangement is less than when the light is once reflected from a looking-glass.

Electric Communications without Wires.—It would seem from recent experiments that it is perfectly possible to convey a message for a certain distance along the earth without any conducting wire whatever. But M. Th. Du Moncel has explained to the French Academy (May 8) that the idea of communication without wires is far from novel, having been experimentally tested thirty years ago, both in England and America. Thus, messages were sent from Gosport to Portsmouth (and, we believe, across to the Isle of Wight), a distance of about 3 kilometres.

Ice-making Machines—Professor Hoffmann has the following account in the "Chemical News," May 12, of a novel form of ice-machine. He says that since the beginning of 1873 Nehrlich & Co., of Frankfort-on-the-Main, make the Windhausen machine with two cylinders of one size only, with especial regard to the demand in breweries. It requires a 40-horse power engine, and is guaranteed to yield hourly 2,500 cubic metres of air at temperatures of from $-30°$ to $-50°$. If we assume that these temperatures refer to initial temperatures of from 10° to 30°, the total reduction of temperature amounts to 60°, whence the amount of the negative heat units may be calculated as 50,000, corresponding at most to 400 kilos. of ice. If the production of ice were the object in view, the same quantity of air might

be made to circulate. A steam-engine of 40-horse power consumes hourly 80 kilos. of coal; consequently 1 kilo. of coal would give 5 kilos. of ice—a very favourable result. Such a machine, including the engine, cost in 1873 66,000 marks (3,300*l.*) The sum certainly seems immense.

ZOOLOGY AND COMPARATIVE ANATOMY.

The "Challenger" Expedition.—Since our last issue this expedition has come to a conclusion. Much of the work, however, remains to be published, and will occupy the different members of the staff for the next six or nine months. All that has been published concerning her trip around the world will be found in the long and important paper which was published in an earlier number by W. F. Galton, F.R.C.S.

Snakes that Eat Snakes.—One of these creatures, which is now at the gardens of the Zoological Society, has, during its stay in this climate, devoured an enormous number of the common English snake. We learn from an American contemporary that some years ago Professor Cope described the snake-eating habits of the *Oxyrrhopus plumbeus* (Wied), a rather large species of snake which is abundant in the intertropical parts of America. A specimen of it from Martinique was observed to have swallowed the greater part of a large *fer-de-lance*, the largest venomous snake in the West Indies. The *Oxyrrhopus* had seized the *fer-de-lance* by the snout, thus preventing it from inflicting fatal wounds, and had swallowed a greater part of its length, when caught and preserved by the collector. More recently a specimen was brought by Mr. Gabb from Costa Rica, almost five feet in length, which had swallowed nearly three feet of a large harmless snake (*Herpetrodryas carinatus*) about six feet in length. The head was partially digested, while three feet projected from the mouth of the *Oxyrrhopus* in a sound condition. The *Oxyrrhopus* is entirely harmless, although spirited and pugnacious in its manners. Professor Cope suggests that its introduction into regions infested with venomous snakes, like the island of Martinique, would be followed by beneficial results. The East Indian snake-eater, *Naja elaps*, is unavailable for this purpose, as it is itself one of the most dangerous of venomous snakes.

Singular Custom adopted by a Tree-Frog.—Professor Peters has lately described the mode of deposit of its eggs employed by a species of tree-frog (*Polypedates*) from tropical Western Africa. This species deposits its eggs, as is usual among batrachians, in a mass of albuminous jelly; but instead of placing this in the water, it attaches it to the leaves of trees which border the shore and overhang a water-hole or pond. Here the albumen speedily dries, forming a horny or glazed coating of the leaf, inclosing the unimpregnated eggs in a strong envelope. Upon the advent of the rainy season, the albumen is softened, and with the eggs is washed into the pool below, now filled with water. Here the male frog finds the masses, and occupies himself with their impregnation.

Crustacea of the North Pacific Exploring Expedition.—It was supposed that the papers of Dr. Stimpson describing these crustacea had been destroyed.

However, the "American Naturalist" tells us that a careful examination of the papers left at the Smithsonian Institution by the late Dr. Stimpson has revealed the existence of the complete MSS. of his final report on the Crustacea of the North Pacific Exploring Expedition as far as the end of the Anomoura, with beautiful figures of one hundred and thirty-seven of the new species. It was supposed that these had perished with Dr. Stimpson's other MSS., and with the collections they described, in the great Chicago fire. It hopes they will soon be published.

A New Tænia from Rhea Americana.—At a recent meeting of the Philadelphia Academy of Sciences, Dr. Chapman called the attention of the members to a new species of tænia which he had found in the alimentary canal of the *Rhea Americana.* According to Diesing there exists in the Struthio a tænia, but as no description is given he could not say whether the species are the same. It is very probable, however, that they are so. If future investigation should show this to be correct, it will offer another illustration of closely related forms having the same entozoa. The tænia from the *Rhea* varies from nine to ten inches in length. Its head measures $\frac{1}{33}$ of an inch in breadth and $\frac{1}{25}$ of an inch in length (to beginning of first segment). The head is provided with four suckers. The cervical segments are rounded off at the articulations, but the mature ones are serrated. The genital aperture is lateral, and alternates from side to side. Sometimes there will be as many as five successive segments on one side exhibiting these apertures, and then five will be seen on the opposite side of the next five successive segments. The penis could be protruded by compression, and the vagina readily seen. From the fact of the head being rather thickly set upon this species, the name *Tænia tauricollis* was proposed for it.

The Mammals of the Assyrian Sculptures.—The Rev. W. Houghton, who is a well-known contributor to this journal, recently read a paper on the above subject before the Society of Biblical Archæology (May 2, 1876). Beginning with the order Quadrumana, Mr. Houghton said two species were represented. He referred to the absurdly human appearance of the monkeys of the sculptures: the face is that of a man with a fringe of whiskers round it neatly trimmed, but one figure more true to nature indicates the species of monkey—viz., *Presbyter entellus,* the Hoonuman of India, or some closely allied species. There was also another species, the *Macacus Silenus.* The Assyrian word for monkey was *u-du-mu,* the same as the Hebrew word *Adam,* "a man;" compare our "anthropoid ape." Of the order *Feræ* there are mentioned the lion, the hyena (in Accadian *Lig-bar-ra,* "striped dog"); the bear, *Ursus syriacus,* especially as being of various colours, and the leopard. Other wild animals were the hare, *Lepus sinaiticus* (*ka-zin-na,* "face of the desert"); the wild bull, which was clearly a *Bos* and not a *Bubalus,* most probably *Bos primigenius* of the tertiary period; the wild goat (*Capra sinaitica*), the Asiatic steinboc or ibex; the wild sheep (*Caprovis orientalis*), the wild deer (*Cervus mesopotamicus*), and other species, *Cervus elaphus* and *Cervus Maral,* or Persian deer; the gazelle (*G. Dorcas*); the wild ass (*Equus hemippus*); the elephant (*Elephas indicus*); the rhinoceros, or, as it is called on the black obelisk of Shalmaneser, "the ox from the river Saceya;" and the wild boar (*Sus scrofa*).

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